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TO THE HISTORY OF RUSSIAN SCIENCE: ACADEMICIAN NICHOLAS IVAN VAVILOV ON HIS 70TH ANNIVERSARY (NOVEMBER 26, 1887-AUGUST 2, 1942)

By F. KH. BAKHTEEV (BAKHTEYEV)

[Translated and condensed by James G. Dickson, University of Wisconsin, from the *Byulleten Moskovskogo Obshchestva Ispytatelei Prirody, Otd. Biologii*, 63 (3): 155–165. 1958. Transliteration of the Library of Congress is used.]

This paper was given before the Genetics Section of the Moscow Society of Natural Science on November 26, 1957; before the joint session of the Geographical Society of USSR and the All-Union Botanical Society in Leningrad, December 6, 1957; and in Moscow on January 11, 1958 before the students of the Timiryazev Academy. A review, by I. Grebenschikova and F. Schultz, was printed in Der Züchter, *28 (4): 161–166 (1958).*

TODAY we commemorate the seventieth birthday of Nicholas Ivan Vavilov, one of the most distinguished, international scientists of our country. He directed his abilities, his creative energies, and all the power of his fertile mind towards biological science to serve his country, especially in the dynamic, functional phases of botany, genetics, and pathology in relation to the origin, distribution, and improvement of cultivated plants."

N. I. Vavilov was born in Moscow, the son of a prominent merchant. He with his brother, Sergi, a physicist and later President of the Academy of Science of USSR, and his sister, Lidia, a microbiologist, obtained their early education in Moscow. Vavilov entered the "Petrovke" Agricultural institute, later named the Timiryazev Academy, in 1906. His early teachers were D. N. Pryanishchnikov, soils and plant chemistry; N. M. Kulagin, zoology and entomology; and C. I. Rostovtsev, botany and phytopathology. His dissertation, "Snails as Pests in Fields and Gardens," published in 1910, received an award from the Bogdanov Museum in Moscow.

After graduation he continued his studies and preparation for a professorship. He was first at Poltava Agricultural Station, then at the Institute of Plant Culture under D. L. Rudzinsky and S. I. Zhegalov where he initiated the studies on immunity of plants to parasitic fungi and the anatomical variants in *Avenae*. In 1911–12 he was assistant in economic botany in Petersburg (Leningrad) under Professors R. Z. Regel and A. A. Yachevsky (Jaczewski), where he advanced the studies on immunity, experimental phylogeny, and variability in plants. These men in 1913 arranged for his graduate study in biological laboratories in England, France, and Germany. He spent much of his time in Bateson's laboratory and private library and with Punnett and Biffen advancing his study on the immunity of cereal plants to diseases; with shorter visits with Vilmorin and Ernst Haeckel.

He returned to Moscow as lecturer in the

"Petrovke" Agricultural Institute and completed his M.S. dissertation, "The Immunity of Plants to Infectious Diseases," in 1914. "The real progress of his investigations under the Soviet era was initiated. He supported with all his ability the progress of the socialistic science in his country."

In 1917 he was appointed professor of genetics, plant breeding, and agronomy in the Agricultural Institute of Voronezh and at the University of Saratov. He presented the paper, "Law of Homologous Series in Hereditary Variability," at Saratov in 1920.

After the death of Regel in 1920, Vavilov was appointed to succeed him as Chairman of the Department of Economic Botany and Plant Breeding in the Agricultural Institute of Petrograd (Leningrad). He held this appointment until the Institute was reorganized in 1924 under the All-Union Institute of Economic Botany and New Cultures, with Vavilov as Director.

Vavilov and Yachevsky attended the International Agricultural Congress held in the United States in 1921. American newspapers wrote about his stay: "If all Russians were like Professor Vavilov the United States should live with Russia in good friendship." These men traveled widely in the United States, England, France, Holland, Germany, and Sweden in conjunction with this trip. Vavilov returned to the USSR with plans crystallized for the reorganization of economic botany and plant industry in the USSR.

The reorganization of agriculture and economic botany in the USSR on a national basis was initiated in 1923. The Agricultural Committee was reorganized into the Governmental Institute of Experimental Agronomy, with Vavilov as Director. The All-Union Institute of Economic Botany and New Cultures of the Council of People's Commissars was founded in 1924 with Vavilov as Director. The All-Union Lenin Academy of Agricultural Sciences was founded in 1929, and the Council of the People's Commissars elected Vavilov as President, which position he retained until 1935. He was a member of the Central Executive Committee of the USSR from 1926 to 1935.

Under his direction a new system of specialized institutes was developed. These were organized on the cultural-crop basis and located in all areas of the USSR.

The All-Union Institute of Economic Botany and New Cultures was reorganized in 1930 under the All-Union Institute of Plant Industry, with Vavilov continuing as its Director until August 6, 1940. Under his direction this Institute pioneered the progressive scientific thinking in breeding and genetics, the origin and phylogeny of cultivated plants, the introduction and geography of cultivated plants, and investigations on their biochemistry, physiology, cytology, and anatomy. The excellent collection of cultivated plants numbered 200,000 forms by 1940. These served for the breeding of now-famous standard varieties. Their culture was studied in all parts of the Union. The researches of a host of investigators were published chiefly in *The Bulletin of Applied Botany, Genetics and Plant Breeding*. "These investigations were the pride of our country; they were world-famous. This is not surprising because many excellent scientists were working cooperatively under Vavilov's direction." (The list of scientists in the several disciplines is given in the original paper.)

The library of the Institute was enlarged and included the major plant science publications of the world; 500,000 volumes were present in 1940.

Vavilov dedicated himself to the publication of the Institute research data. In addition to the *Bulletin* he was editor of *Flora of Cultivated Plants of USSR, Theoretical Basis of Plant Breeding, Handbook of Seed Certification of Agricultural Crops* and *World Sources of Cereals, Legumes, Flax and Their Use in Plant Breeding*. He was author and coauthor of numerous scientific papers published in journals abroad as well as in the USSR.

His scientific contributions were recognized by honors from numerous countries. Honorary Doctorates were awarded by the Universities of Brünn and Sofia. He was elected corresponding member in 1923 and member of the Academy of Sciences of USSR in 1929. He was elected a member of The Royal Society of London, The Scottish Academy of Sciences in Edinburgh, The Royal Leopoldinian Carolinian German Academy of Scientists in Halle, Scientific Council of the Agrarinstitute in Rome, The New York Geographical Society; corresponding member of the Czechoslovakian Academy of Agricultural Sciences; and honorary member of The Royal Horticultural Society of London, The Linnaean Society of London, and The Indian Academy of Sciences. He was Vice-President of the Sixth

and Honorary President of the Seventh International Congress of Genetics. The Soviet literature stressed that "Vavilov was one of those scientists who broke through the blockade that divided us from the rest of the world." (*Nauyanyi Rabotnik*, 1926, No. 11, M., p. 24.)

N. I. Vavilov's scientific contributions evolved from the study of the immunity of plants. The first phase of the research culminated with "Immunity of Plants to Infectious Diseases." He studied intensively the methods of investigation used in the various disciplines of botany. He defined a scheme of classification for the several types of immunity and studied the influence of environment on the expression of disease resistance in plants. He was especially interested in the genetical basis of immunity and the factors conditioning its expression and their natural distribution. These studies led to a functional evaluation of systematics. He observed that in spite of the great diversity of forms, variability was governed by certain laws. He formulated the "Law of the Homologous Series in Hereditary Variability," first published in 1920 and in an expanded English translation in 1922. His further investigations led to the publication of "The Linnaean Species as a System" in 1931 and "The Geographical Basis of Plant Breeding" in 1935. In these publications and in his lectures, he formulated "a design of the creative development of the Darwinian doctrine." "According to Valvilov's concept, breeding means evolution directed by man."

He started his famous "Geographical Experiments" to investigate the variability of plants in 1923, first at 25, and later at 115 locations in the principal geographical zones of the USSR. The preliminary results were presented at the International Congress of Agricultural Experts in Rome in 1927. The evaluation of the geographical influence on variability suggested the existence of two groups of plants. The duration of the vegetative period was shortened in northern areas in the one and lengthened in the other group. He correlated the differences in response to day-length and changes in the chemistry of the plants that were associated with these reactions. Certain morphological characters remained constant over the range of environments. These he defined as useful for classification. These investigations led naturally to the publications for which he served as editor: "Flora of Crop Plants of the USSR", "Biochemistry of Crop Plants", "Geographical Basis of Plant Breeding" and "World Sources of Cereals, Legumes, Flax and Their Use in Plant Breeding."

The physiological and morphological investigations of varieties and species led him to the central problem of the origin of cultivated crop plants. The interpretation of plant response to environment in relation to geographical distribution and the search for missing forms in the system led naturally to plant exploration. His dynamic leadership was expressed by plant exploration in almost all continents. The detailed records, photographs, observations and plant lists for each expedition are filed in the Plant Institute Library and many reports were published. The species and varieties collected were propagated and studied at one or more of the geographical stations in USSR. Many new forms were used in the practical breeding of crop plants.

The results of these investigations were presented in a series of publications. The preliminary summary, "Studies on the Origin of Cultivated Plants," was published in 1926; "The Geographical Regularities in the Distribution of Genes of Crop Plants," in 1927. Shorter articles on the origin of cultivated plants appeared in the *Bulletin of Applied Botany, Genetics, and Plant Breeding* and "The Doctrine of the Origin of Cultivated Plants at the Time of Darwin" resulted in the Lenin Award.

The investigations of Vavilov and his associates were the basis for the definition of eight major centers of the origin of crop plants. Each of these centers was characterized by detailed descriptions and a comprehensive list of the endemic crop plants and their allied species. The centers were defined chiefly on the basis of the high diversity of forms concentrated in these centers.

Vavilov was interested in the ecological classification of crop plants. The summary of his investigations and their application to systematics was published in 1940 in "New Systematics of Cultivated Plants."

In later years he and his associates initiated systematic crossing of different ecological groups (ecotypes) of cereals, legumes, and other plants. These experiments were designed to develop new methods and theories for scientific crop breeding and for the solution of problems in

the species genetics of crop plants. These experiments were to serve also as the basic material for his "Plant Cultivation in USSR" unfinished at the time of his death.

He directed much attention to the introduction of economic plants into the northern, arid, and tropical regions of USSR. Through expeditions and exchange, new and valuable plants were introduced and selected for adaptation. Among these were citrus, chincona, jute, tung, rubber, and plants for aromatic oils, pharmaceuticals, and tannins.

Vavilov was interested in the history of agriculture. In all of the expeditions, the collection of notes and photographs on agricultural methods, tools, household equipment, and their use and development were of foremost importance. In 1940 shortly before his removal from office he had arranged for a conference at Kiev on the preparation of material on the history of agriculture.

In addition to his being recognized as a biologist of renown, he was a well-known geographer. As a student his first geographical exploration into the North Caucasus and Transcaucasian Mountains was in 1908. In 1916 most of North Iran was explored; on this trip the original cereals without ligules were found. From 1917 through 1921 the Southeastern European agriculture was studied in great detail by areas. In 1921 and 1922 he traveled extensively in the United States and Canada. Afghanistan, including Kafiristan, was studied in 1924. On the basis of this report he was awarded the "Przhevalsky Medal" by the Soviet Geographical Society. In 1925 the Khivin oasis and Uzbekistan were studied. All of the areas of the Mediterranean basin were included in the expeditions from 1926 through 1927. In 1929 he traveled extensively in China, Japan, Korea, and Formosa and into Central America and Mexico; in 1931 in Denmark and Sweden; and in 1932 and 1933 he and associates explored the major areas of South America. The Transcaucasian mountains and the Armenian Highlands were his favorite collection grounds. The remotest spots in this high plateau of plant diversity were visited during the summer on numerous occasions.

In discussing questions concerning genetics and breeding, Vavilov maintained a scientifically well-founded position which was fully confirmed later. He tested a representative group of corn hybrids from the United States at locations from Tiflis northward to near Moscow in 1930. [This information is added by the reviewer, who furnished the seed of corn hybrids representing a range in dates of maturity and cooperated in the experimental planting, observations, and collecting data.] Following this test he recommended the introduction of double-cross hybrids and the initiation of a corn inbreeding and selection program in USSR. This development in methods of crop improvement and others involving the application of modern genetic principles met with strong opposition, and therefore, his ideas were not advanced. "Today, however, we are witnesses to the promotion of a governmental program for growing double-cross corn hybrids that was recommended by Vavilov. Such examples are numerous and they serve as evidence of his sound concepts which he defended uncompromisingly until the end."

"The success of the All-Union Institute of Plant Industry and of the Institute of Genetics and the Academy of Science of USSR through 1940 was always connected with his name. The Institute of Plant Industry always considered the development of the socialistic progress of our country. Vavilov worked in all divisions of the Institute as its tireless leader. All who made his acquaintance wondered from what source he got his great energy. When one of his colleagues would remind him of the necessity for some recreation, he would always say, patting the speaker on the shoulder: 'My friend, life is short; one must hurry'."

Vavilov was the first to publicize the work of I. V. Michurin. Lenin probably obtained the first information regarding the Michurin investigations indirectly from Vavilov through N. P. Gorbunov, then director of the People's Commissars. A close friend of Michurin, C. P. Lebedeva wrote in 1956 in his memoir of Vavilov (Remembrances of N. I. Vavilov, manuscript, 1956, 6 pp.) "... in 1924 Vavilov promoted the honoring of Michurin on his fiftieth anniversary of service and he quotes Michurin as follows:" 'Nicholai Ivanovitch Vavilov was here. What a nice person he is: a clever mind, a great scientist and a good soul. He helped us very much, and how he loves all new things'. "Such memories are not rare."

"As I reach the end of my presentation, I feel that it is fragmentary and not nearly as harmonious and comprehensive in character as such a great scientist as Vavilov deserves. His later biographies would present without doubt, more complete substance that would better characterize the personality and the spirited drive of this famous scientist. N. I. Vavilov is our national pride. He served his people with great love and he dedicated the full creative power of his 55 years to scientific truth and to the free growth of science for the benefit of the world."

PARAMUTATION AND CHROMOSOME ORGANIZATION

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ABSTRACT

Two processes, mutation and paramutation, are postulated to account for the observed heritable changes in the immediate R *region of chromosome 10 in maize. Mutation is sporadic, undirected, and yields stable alleles having distinctive effects on aleurone and plant pigmentation. Paramutation occurs invariably in certain heterozygotes, is directed, and gives unstable alleles conditioning intergrading phenotypes. The paramutant phenotype is* R*-locus dependent, but paramutagenicity and pigment production are separable functions. Paramutation occurs in somatic cells; and paramutable* R *alleles are widespread in* Zea mays. *An* R *factor in a heterozygote with a strongly paramutagenic allele may itself become weakly paramutagenic. Reciprocal translocations involving chromosome breaks at remote points, proximal or distal to* R, *and in coupling with the latter, increase pigment-producing action of* R, *and render* R *comparatively insensitive to paramutation in* R^{st} *heterozygotes. These effects are not immediately detectable following introduction of* R *into a translocation chromosome but, once established, they persist for at least one generation after return of* R *by crossing over to a structurally normal chromosome.* R *is relatively insensitive to paramutation when carried by an abnormal chromosome 10 containing a large heterochromatic knob. The meaning of paramutation for chromosome organization is conjectural. The evidence is discussed in relation to a hypothesis in which it is assumed that the chromosome comprises two classes of components, and operates as an information exchange during differentiation and development of the organism. The occurrence of paramutation in other organisms than maize is considered, and it is concluded that possibly paramutation may be a very general phenomenon.*

INTRODUCTION

TWO classes of germinally transmissible changes are now known to occur at, or very near, the *R* locus in maize, mutation and, what we have chosen to call, paramutation (Brink, 1958). An operational distinction between the phenomena in this case is readily made. Mutation is sporadic, stepwise, undirected, and yields stable alleles of *R*, whereas paramutation occurs invariably in certain heterozygotes, is directed, and the alleles thus arising are metastable, and seemingly vary continuously in level of action. The meaning of paramutation for chromosome organization is conjectural at present. The particular thesis that will be outlined later in the present article, following a review of the experimental data on *R* paramutation, assumes that the genonema is of a dual nature, incident upon its heterocatalytic function, and that mutation and paramutation reflect alterations in the two respective kinds of components.

The prevailing concept concerning organization of the genetic substance, brought to focus in the Watson and Crick (1953) model of DNA, rests upon a factual basis of extraordinary breadth and refinement. In what respects does this general framework of ideas require modification to accommodate the unconforming evidence from paramutation, and from the probably correlative phenomena associated with unstable loci? The answer to this question is largely unknown. In fact, the evidence is still too scanty to indicate clearly in what direction the answer should be sought. Various propositions might be formulated, therefore, as guide lines to the additional exploratory work needed, between which there would be little choice at present. The particular hypothetical scheme selected for discussion here is thus but one of the possibilities that should be envisioned. It serves, however, to illustrate the nature of a significant biological problem that is unsolved and to redirect attention to the chromosome in a relationship long recognized as perhaps fundamentally important, but which has been little studied.

DESCRIPTION OF *R* ALLELES

The *R* locus, on the long arm of chromosome 10 in maize, conditions anthocyanin formation in the aleurone and certain vegetative parts of the plant,

including the seedling and anthers. (The aleurone is the outer layer of cells of the triploid endosperm in the seed, and is a product of the secondary fertilization occurring in Angiosperms whereby a *2x* chromosome complement is contributed to the primary nucleus by the maternal, and an *x* complement by the paternal parent.) Four classes of *R* alleles are of wide occurrence in *Zea mays*. R^r symbolizes a rather numerous group of factors differing in minor ways on pigmentation of both seed and plant (Stadler, 1951). A single representative of this class, termed standard R^r, was used in the present experiments, except where noted otherwise. Standard R^r conditions self-colored aleurone in three or two doses ($R^rR^rR^r$ or $R^rR^rr^r$) and darkly mottled aleurone in single dose ($R^rr^rr^r$). The r^g allele is the bottom recessive in the series, and gives colorless aleurone and green plant (no anthocyanin). R^g and r^r are complementary in their effects on aleurone and plant pigmentation. R^g differs from R^r in giving green, rather than red, plants, whereas r^r conditions colorless aleurone and red plant. *R* is dominant to *r* in the aleurone, and super-r to super-g in the plant.

Stippled (R^{st}) and marbled (R^{mb}) are aleurone spotting factors. They have not been observed to mutate to each other, and so may be of independent origin. The former gives a fine, and the latter a coarse, pattern. Both condition green plant. R^{st} and R^{mb} are unstable alleles. Although the point cannot be proved directly, it is reasonably certain that the pigmented aleurone spots on stippled and marbled seeds are the result of mutations in endosperm tissue of the R^{st} and R^{mb} alleles from unstable colorless to stable colored forms. The spotting pattern on stippled kernels is relatively constant on a given genotypic background. The marbled allele, on the other hand, varies rather widely in expression from plant to plant, and apparently is "unfixable" at any level. The frequencies of germinally transmissible mutations of stippled and marbled to self-color are relatively high also. (Accurate rates cannot yet be given because, contrary to an earlier assumption, a significant proportion of seeds with phenotypically stippled or marbled endosperms have been found to contain embryos carrying a mutant self-colored allele.) The R^{st} and R^{mb} alleles occur occasionally in maize strains native to Peru and neighboring countries, but apparently not elsewhere. They are of special interest in the present study as the primary sources of chromosome components that promote paramutation at the *R* locus.

TECHNIQUES

All the *R* alleles used in the present studies have been incorporated in a common highly inbred commercial yellow dent strain, known as W22. The pigment-producing action of a given *R* factor is best disclosed when the allele is present in the aleurone in single dose, heterozygous with colorless (*R r r*). The standard testing procedure, therefore, is to apply pollen from a plant carrying the allele whose phenotypic effect it is desired to evaluate to the silks of a colorless strain, and then to score the resulting mature kernels for grade of aleurone color. The W23 inbred strain commonly used as the pistillate parent in such matings carries the r^g allele, thus permitting definitive separation, by sprouting the seeds and noting seedling color, of any two classes of testcross kernels that give overlapping aleurone phenotypes, but differ in their plant color components (e.g., r^gr^g ♀ × R^rR^g ♂).

Many, but not all, R^r and R^g alleles, and all the paramutant forms of these factors, display quantitatively varying degrees of pigmentation (mottling) when present in single dose in the triploid aleurone, following a testcross on an r^gr^g plant. These complex phenotypes usually are scored against a set of standard kernels varying in grade from colorless, through five levels of mottling, to self-colored aleurone. Highly repeatable results on coded samples are usually attainable when 60 or 80 kernels per testcross ear are thus evaluated.

MUTATION OF STANDARD R^r

When W22 standard R^rR^r plants are pollinated on a large scale with W22 r^g pollen, three principal kinds of mutations appear among the offspring, R^g, r^r, and r^g. The numbers of verified mutations found relative to the numbers of gametes tested were: R^g, 10/33,500; r^r, 205/176,244; and r^g, 2/176,244. These values correspond to rates of 3.0×10^{-4}, 11.6×10^{-4}, and 0.11×10^{-4}, respectively. The only exception, observed in our tests, to the three mutant classes mentioned above was a single kernel that was found to carry an allele indistinguishable from standard R^r except that it gave pale, rather than dark purple aleurone. Two processes are suggested by Stadler and Emmerling (1956) and by Emmerling (1958) as being involved in the production of R^g and r^r mutants from R^r (i) intragenic changes whereby a postulated S component (seed color) mutates to s (colorless), giving r^r, and a corresponding P component (red plant) mutates to p (green plant), giving R^g, and

(ii) recombination by crossing over following oblique synapsis of the P and S elements in homologous chromosomes, resulting in the formation, among other possible derivates, of a chromosome strand carrying P alone (r^r) or one carrying S alone (R^g).

Our mutation experiments were made with a particular question in mind, and have no bearing on the above hypothesis. It was desired merely to determine whether the allele we were designating "standard" R^r, and which had just been found to undergo paramutation invariably in heterozygotes with stippled (R^rR^{st}), as will be described later, was comparable to the larger sample of R^r alleles tested by Stadler (1948) when stability was measured in the same way. Several R^r alleles, varying in geographic origin and in effect on plant color, were observed by Stadler to range in mutation rate to r^r from zero, or low values, to about 20×10^{-4}, depending upon both intrinsic differences and genotypic background. The observed value for standard R^r, 11.6×10^{-4}, falls well within these limits. It may be concluded, therefore, that the R^r allele extensively employed in the present experiments is representative of its class, according to this criterion.

As a background against which paramutation of R^r may be examined later, the general characteristics of the mutations of R^r may be listed as follows: (i) The mutations fall into a small number of sharply discontinuous classes. (ii) The frequencies, although significantly higher than those Stadler (1942) observed for six other loci conditioning different endosperm characters in maize, are still far below the levels characteristic of unstable factors, such as c^{m-1} (McClintock, 1951) or variegated pericarp (Brink and Nilan, 1952). (iii) Mutations to levels of seed and plant pigmentation intermediate between full expression and no expression are very rare. (iv) The mutants derived from R^r are stable, in the same sense that the parent allele is stable. Tests which we have made, for example, revealed no mutations to r^g among 62,758 gametes representing nine r^r mutants from standard R^r. A comparable experiment involving seven R^g mutants from standard R^r yielded 25 colorless kernels among 111,729 kernels scored. (19 of these colorless mutants arose from a single R^g allele.) The proportion of the presumed r^g mutants that will transmit r^g has not yet been determined, but it is evident from the crude values that R^g changes infrequently to another form.

It may be noted at this point also that homozygous paramutant R^r was observed to mutate to r^r at the rate of 9.21×10^{-4} (60/65,163). This value is not significantly different from the rate for standard R^r (11.6×10^{-4}) in the same genetic background.

PARAMUTATION OF STANDARD R^r

A very different set of facts confronts us when we turn from the data on mutation to those on paramutation of R^r. Evidently two unlike systems of heritable variation are operative at, or in the vicinity of, the R^r locus.

The general features of paramutation of R^r have been discussed elsewhere (Brink, 1958a), and so will be reviewed here only briefly. The results of three matings (a) r^gr^g ♀ × R^rR^r ♂, (b) r^gr^g ♀ × $R^{st}R^{st}$ ♂, and (c) r^gr^g ♀ × R^rR^{st} ♂ illustrate the central point. All the kernels resulting from testcross (a) have darkly mottled aleurone, and all those from mating (b) are stippled. Since R^r and R^{st} are alleles, the prediction on Mendelian grounds, therefore, would be that the third testcross, (c), would yield equal numbers of darkly mottled and stippled kernels. The observed result, however, is a population of kernels half of which are stippled, as expected, and complete replacement of the darkly mottled class by another phenotype in which the aleurone is weakly pigmented. The genetic significance of the latter fact becomes apparent when it is found that R^r is not recoverable in standard form among the descendants of mating (c). Tests of the R^rr^g and $R^{st}r^g$ progeny from the respective (a) and (b) matings yield conventional results, as do the $R^{st}r^g$ plants derived from the (c) testcross. The R^rr^g plants arising from r^gr^g ♀ × R^rR^{st} ♂ crosses, however, give an anomalous result. When pollen from them is applied to r^gr^g individuals the $R^rr^gr^g$ kernels formed are again weakly colored. Or, if the R^rr^g plants in question are self-pollinated, and the R^rR^r and R^rr^g offspring are then testcrossed on r^gr^g ♀ ♀, all the resulting $R^rr^gr^g$ kernels are deficient in aleurone pigmentation. There is some reversion of modified R^r in all these cases toward the standard level of R^r action but, contrary to an earlier statement (Brink, 1956), the amount is variable in all genotypes thus far tested, and methods of blocking the process or of promoting it in regular ways have not been discovered. The R^{st} allele seemingly is unchanged in R^rR^{st} plants.

It is evident from the experimental results just reviewed that the pigment-producing action of the R^r allele is reduced by passing the factor through

a heterozygote with stippled, and that the change tends strongly to persist in subsequent generations. In the terminology we have adopted, R^r has undergone paramutation. The R^{st} allele, which invariably promotes this change in R^rR^{st} plants, is said to be paramutagenic. A paramutant R^r allele derived from an R^rR^{st} individual may be designated $R^{r:st}$ or, more conveniently, $R^{r'}$. Because of its simplicity the latter term will be employed in the present article to denote paramutant forms of R^r, in general. When so used, $R^{r'}$ is to be understood not as a single unvarying entity but as any one of a series of paramutant alleles showing reduced pigment-producing action, as compared with standard R^r. Other experiments (Brink and Mikula, 1958) show that the pigment-producing action of the R^r allele is reduced also in the vegetative tissues of R^rr^g seedlings and adult plants derived from r^gr^g ♀ × R^rR^{st} ♂ matings. Thus, if the R^r allele comprises two distinct components conditioning anthocyanin formation, one acting on the seed and the other on the plant, both are affected by paramutation.

The marbled allele (R^{mb}), like stippled, is strongly paramutagenic in R^rR^{mb} heterozygotes (Brink and Weyers, 1957). Weyers (1959) has found that the paramutagenic action of R^{mb} is more variable in intensity than that of stippled, but that it is not correlated with density of aleurone spotting.

Additional aspects of paramutation will be described later in the present article. Meantime those features of the phenomenon already mentioned may be summarized by way of contrast with the corresponding characteristics of mutation. (i) Paramutation invariably occurs under the conditions stated, that is, 100 per cent of the R^r gametes formed by R^rR^{st} or R^rR^{mb} plants are paramutant. (ii) It is directed, both in the sense that R^{st} regularly promotes the change in R^r in R^rR^{st} plants and that R^r responds in a particular way. (iii) The paramutant forms of R^r are metastable and, when those from all known sources are considered, appear to comprise a continuous series of wide amplitude in terms of aleurone pigment-producing action.

It may be inferred from these results that mutation and paramutation of R^r are distinct processes.

LOCUS DEPENDENCE OF PARAMUTATION

Evidence already has been published excluding an autonomous cytoplasmic element as the genetic basis of paramutation (Brink, 1958b). Additional data are now at hand confirming this conclusion, and demonstrating directly that the phenomenon rests upon heritable change at, or in the immediate vicinity of, the R locus.

A series of R^g mutants from standard R^r were isolated in the W22 inbred line. These mutants were found to be indistinguishable from the parent allele in aleurone pigment-producing action, and all proved to be highly paramutable in R^gR^{st} heterozygotes. R^r and R^g seeds differ, however, in that the former, when sprouted, yield red seedlings, whereas the latter give green seedlings.

Possession of the R^g mutants made possible testcrosses on r^gr^g ♀ ♀ of plants of the following two kinds (i) $R^rR^{g'}$ (from stock R^rR^r × R^gR^{st} matings) and (ii) $R^gR^{r'}$ (from stock R^gR^g × R^rR^{st} matings). Two classes of kernels in equal numbers, darkly mottled and weakly mottled, should result from each of these testcrosses, on the hypothesis that a reduction in aleurone color will follow in inheritance the member of the allelic pair (distinguishable by seedling color) that is derived from a stippled heterozygote, in which it has undergone paramutation. Tests of this sort were made by D. F. Brown in our laboratory, using eight R^g mutants of independent origin. Kernels from each testcross ear were scored individually for aleurone pigmentation, and were then separated into the two respective classes, R^r and R^g, by sprouting the seeds and recording seedling color (Fig. 1). Statistically significant differences in grade of aleurone color between classes were found in each case and, throughout the two series, the more weakly pigmented class was that represented by the allele, either R^r or R^g, that had been passed through the heterozygote with stippled.

Earlier experiments, using pollen from $R^rR^{r'}$ plants (derived from standard R^rR^r × R^rR^{st} matings) in testcrosses on r^gr^g ♀ ♀, had shown that the resulting kernel populations gave bimodal distributions for aleurone pigmentation. On some ears two, about equally frequent, phenotypes were clearly in evidence, as would be expected if the R^r allele from the $R^rR^{r'}$ parent were strong, and $R^{r'}$ were weak, in pigment-producing action. On other ears of the same origin a pronounced overlap of the two presumed kernel classes was observed, even though numerous lightly colored kernels were still present in these cases. It seemed doubtful that the extensive overlap could be fully accounted for in terms of reversion of the $R^{r'}$ allele toward the normal R^r level of action in the $R^rR^{r'}$ parent, although other data indicated that such partial re-

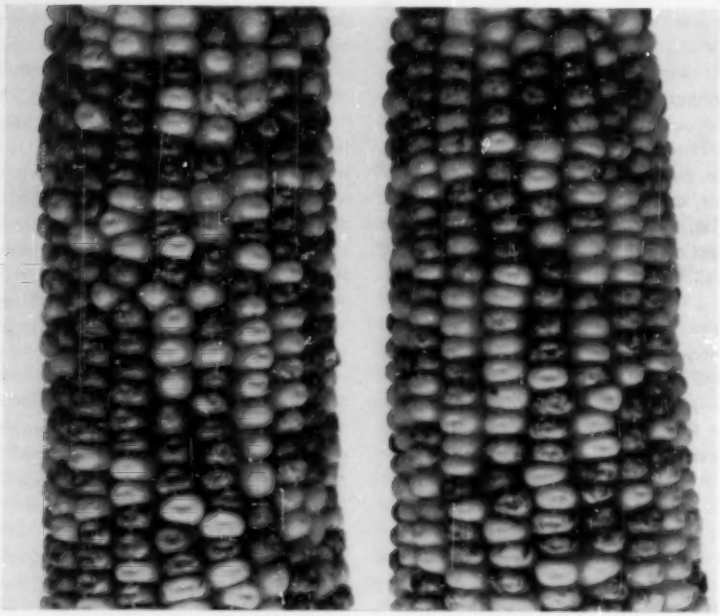

FIG. 1. MENDELIAN DISTRIBUTIONS OF DARKLY MOTTLED AND WEAKLY PIGMENTED KERNELS ON TESTCROSS EARS FROM TWO DIFFERENT $r^g r^g$ ♀ × $R_s^g R^r$ ♂ MATINGS, PROVING THAT THE PARAMUTANT ALEURONE PHENOTYPE IS *R*-LOCUS DEPENDENT

Left: R_s^g allele was derived from an $R_s^g R^{st}$ heterozygote, and R^r came from an $R^r R^r$ stock culture. The 50 per cent of weakly pigmented kernels, on sprouting, yielded green seedlings ($R_s^{g'}$), and the darkly colored kernels gave red seedlings (R^r). *Right:* The R_s^g allele was derived from a $R_s^g R_s^g$ stock culture, and R^r came from an $R^r R^{st}$ heterozygote. The 50 per cent weakly pigmented kernels, in this instance, gave red seedlings ($R^{r'}$), whereas the darker kernels yielded green seedlings (R_s^g).

version was probably a contributing factor. The same tendency toward phenotypic overlap was in evidence in the testcrosses involving the $R^{r'} R^g$ and $R^r R^{g'}$ plants just mentioned. Further analysis of the latter disclosed the reason for this behavior, and brought to light an additional aspect of paramutation at the *R* locus. The relevant evidence is reviewed in the next section.

PARAMUTAGENIC ACTION OF $R^{r:st}(R^{r'})$

It is found that standard R^r, on being passed through an $R^r R^{st}$ plant, not only is changed to a paramutant form, $R^{r'}$, but also becomes paramutagenic, although weakly so, as compared with the stippled allele. This fact was demonstrated by comparing the aleurone color grades of $R^g r^g r^g$ kernels derived from testcrosses on $r^g r^g$ ♀ ♀ of otherwise comparable $R^r R^g$ and $R^{r'} R^g$ plants. The R^g alleles used in the test were the eight mutants from standard R^r of this type referred to previously. As already mentioned, R^r and the R^g mutants derived from it are indistinguishable in aleurone pigment-producing action. Following passage through an $R^{r'} R^g$ individual, however, each of the eight R^g mutants tested was found to be slightly but significantly lower in pigment-producing action than its counterpart derived from a control $R^r R^g$ plant. It may be concluded from these results that in $R^r R^{st}$ plants the R^r allele acquires from its stippled partner the capacity of the latter to promote paramutation, but at a reduced level.

The method by which this change in R^r is effected is unknown. Data have been presented in a previous article (Brink, 1958a) supporting the conclusion that the paramutagenic action of R^{st} is not depleted by virtue of exercising this function repeatedly in $R^r R^{st}$ plants. There is no evidence, therefore, that R^r becomes weakly paramutagenic by partial loss of the latter function by its R^{st} partner.

SEPARABILITY OF THE PIGMENT-PRODUCING AND PARAMUTAGENIC FUNCTIONS AT THE *R* LOCUS

Evidence from three sources shows that pigment-producing action based upon the *R* locus and the capacity to promote paramutation vary independently of each other. This fact suggests that the two functions rest upon distinct chromosomal components.

The R^{st} allele gives rise to germinally transmissible stable mutations to self-color at a rate known to exceed 17.1×10^{-4} (possibly by twofold, or more). These self-colored mutants are symbolized by R^{sc}, in order to distinguish them conveniently from R^{g} alleles of other origins. Tests for paramutagenic action have been made with 111 such R^{sc} mutants in heterozygotes with standard R^{r}. Three categories of mutants may be tentatively recognized on the basis of these trials. The members of one group, comprising 41 mutants, were uniformly paramutagenic at, or near, the R^{st} level. The change in aleurone phenotype from an irregular fine spotting to uniform self-color is not accompanied, in these cases, by detectable alteration in paramutagenic function. At the other extreme were 21 R^{sc} mutants that have shown no paramutagenic action in $R^{r}R^{sc}$ heterozygotes. The capacity to promote heritable change in standard R^{r} appears to have been lost by the members of this group. Between these two well-defined categories are 49 R^{sc} mutants that are similarly stable for aleurone pigmentation but which vary widely in paramutagenic action for reasons at present unknown. Numerous tests, extending over several years, reveal that paramutagenicity of the unstable stippled allele varies slightly and irregularly in different W22 plants, but always around a rather well defined norm for a high level of action. The tests with $R^{r}R^{sc}$ plants, on the other hand, show that when R^{st} mutates to self-colored aleurone paramutagenic action may be retained at the original level, may be abolished, or may be altered in other ways not yet analyzed. It follows from these results also that instability for *R* aleurone color expression, as promoted by the R^{st} and R^{mb} alleles, is not a necessary condition of paramutagenicity.

Ashman (1960) observed that among 10 r^{r} mutants arising from $R^{r}R^{st} \times r^{g}r^{g}$ matings, five were paramutagenic in $R^{r}r^{r}$ heterozygotes, and the remaining five were non-paramutagenic, like all other r^{r} factors tested. The level of paramutagenic action in the former group was about equal to that of the stippled allele, and seedling color was typical for the r^{r} class of factors. Critical data on the point are lacking, but these five r^{r} mutants appear to be recombinants between the R^{r} and R^{st} alleles in the heterozygous parent in that they possess the red plant color component of standard R^{r} and the paramutagenic element characteristic of R^{st}. Whatever the process by which the factors arose, the occurrence of these strongly paramutagenic r^{r} alleles shows that paramutagenicity is separable and distinct from the components of the *R* locus basically responsible for aleurone and plant color. The equivalence in level of action of the paramutagenic r^{r} alleles and R^{st} shows that the paramutagenic component of the latter may recombine as a unit. This result is in contrast with the fractional acquisition of paramutagenicity by R^{r} from R^{st} in $R^{r}R^{st}$ plants.

Further evidence supporting the conclusion that composition of the *R* locus with reference to factors conditioning seed and plant color may vary independently of paramutagenic action has recently been obtained from an unusual source. Among 138 offspring from a $R^{mj}/R^{st}/r^{g}$ ♀ $\times$ $R^{r}R^{r}$ ♂ mating, of which 137 were distributed among the six classes normally expected from such a trisomic pistillate parent, a single (disomic) individual occurred that proved to be heterozygous for R^{r}, as expected, and a hitherto unreported *R* allele which seemingly combines the properties of the Navajo (R^{mj}) and R^{st} factors. The Navajo allele restricts pigmentation mostly to a solidly colored patch extending over the crown of the kernel. It is nonparamutagenic in heterozygotes with standard R^{r} (Brink, 1959). The exceptional plant was pollinated by $r^{g}r^{g}$. About half the resulting kernels were self-colored, and the remainder (aside from five with the typical Navajo marking) showed a fine spotting pattern comparable to that of stippled, but differing from the latter in that pigmentation was limited to the crown region, as in Navajo seeds. Among 20 progeny reared from such crown-spotted seeds, and then pollinated by $r^{g}r^{g}$, 19 produced equal numbers of kernels of the new phenotype and colorless, whereas the remaining plant, for reasons unknown, formed typical Navajo and colorless kernels in a 1:1 ratio. Interest in this case in the present connection lies in the fact that the new allele, as tested in the original plant in which it occurred, by applying pollen to an $r^{g}r^{g}$ individual, proved to be paramutagenic at essentially the same level as R^{st} in $R^{r}R^{st}$ sibs. If,

as appears probable from the present limited but suggestive data, the new allele actually is a compound of the R^{ni} and R^{st} factors, then it must be concluded that the paramutagenic action of stippled does not necessarily change when a nonparamutagenic aleurone color factor is introduced into the same chromosome, presumably very close to R^{st}.

By analogy with the results showing that distinct and separable factors in the *R* region condition paramutagenicity and pigment formation in the case of stippled it may be supposed that paramutability of the standard R^r allele also rests upon a different basis than does anthocyanin production. A way of testing the latter possibility, however, has not yet been found.

It is apparent from these considerations that reference to the "R^r allele" as paramutable and "R^{st}" and "R^{mb}" as paramutagenic is probably only a convenient way of speaking. The nature of the apparently heterogeneous structures which these symbols are here used to represent is, of course, the essence of the paramutation problem. A more precise terminology, giving effect to the separate bases of paramutation and pigment production, awaits further understanding of the paramutation phenomenon.

OCCURRENCE OF PARAMUTATION IN SOMATIC CELLS

Independent tests have been made for the occurrence of paramutation at sporogenesis and in somatic cells. The results show that the alteration in pigment-producing action of R^r arises during vegetative development of the plant and not during formation of reproductive cells.

The fact that paramutation involves an interaction of some sort between factors at corresponding positions in homologous chromosomes suggested that, in R^rR^{st} heterozygotes, R^r might be changed to the paramutant form at zygotene in meiosis, when the chromosomes bearing these alleles are conjugated side by side, thus bringing R^r and R^{st} into physical contact with each other. An experiment designed to test this possibility involved testcrosses on r^gr^g ♀ ♀ of R^r heterozygotes of three sorts: R^rr^g, R^rR^{st}, and $R^r/R^{st}/r^g$ (trisomic). Since the r^g allele is nonparamutagenic, whereas R^{st} invariably is paramutagenic, it was expected that testcrosses of the first two types would yield all normal $R^rr^gr^g$ and all paramutant $R^{r'}r^gr^g$ kernels, respectively. These expectations were fulfilled. According to Newton and Darlington (1929) pairing at zygotene in a trisomic set of chromosomes is 2 by 2 at any given level. If, therefore, conjugation between the R^r and R^{st} factors is a condition of paramutation then only about $\frac{1}{3}$ of the R^r gametes formed by $R^r/R^{st}/r^g$ trisomic individuals should be paramutant, and the remainder should be normal. Following r^gr^g ♀ × $R^r/R^{st}/r^g$ ♂ matings, however, it was found that all the $R^rr^gr^g$ seeds formed were of the paramutant phenotype (Brink, 1959). Assuming validity of the Newton-Darlington assumption concerning the mode of chromosome conjugation in such instances, this result excludes zygotene as the stage in plant development at which paramutation takes place.

A particular self-colored (R^{sc}) mutant from stippled, which had been observed in a previous experiment to yield some ears in which the $R^rr^gr^g$ kernels varied widely in degree of aleurone pigmentation, following r^gr^g ♀ × R^rR^{sc} ♂ matings, was used to test for the occurrence of paramutation in somatic cells. It was postulated that R^rR^{sc} plants giving such mixed populations of testcross kernels were chimeras, in which paramutation had proceeded to varying levels, in terms of R^r aleurone pigment-producing potential, in different parts of the staminate inflorescence. The obvious way to test the validity of this idea was to sample the tassel of single plants systematically by collecting pollen from different branches separately, and then to apply these individual lots of pollen to r^gr^g ♀ ♀. When this was done it was observed that, whereas most of the R^rR^{sc} plants gave a uniform result, a few proved indeed to be chimeras. In one individual, for example, the testcrosses gave no evidence that R^r had undergone change in about one-half the tassel, although the pollen grains from the other half were found to carry a paramutant R^r allele. The conclusion that paramutation occurs in somatic cells is also supported by the fact that pollen taken from the tassel surmounting a basal branch (sucker) may give a significantly different result in a testcross on r^gr^g ♀ ♀ than pollen from the tassel on the main stem of the same R^rR^{sc} plant.

It is surmised that the uniform array of weakly pigmented $R^{r'}r^gr^g$ kernels almost invariably obtained following r^gr^g ♀ × R^rR^{st} ♂ matings is attributable to the strongly paramutagenic action of the R^{st} allele and completion of the change of

R^r to $R^{r'}$ in all parts of the tassel before pollen is formed.

GEOGRAPHIC DISTRIBUTION OF PARAMUTABLE *R* ALLELES

R^r and R^g alleles that are paramutable in heterozygotes with stippled are found to be widely distributed geographically. Most of the examples tested were supplied by the Regional Plant Introduction Station, Ames, Iowa. Much of this material was of North American origin, and included various strains currently being grown by Indian tribes west of the Mississippi River in the United States and in Canada. The Ames assemblage also yielded colored aleurone seeds from a few collections originally made in Argentina, Guatemala, Ethiopia, India, and Turkey. Paul Mangelsdorf, Harvard University, kindly supplied four stocks representing Bolivia, Ecuador, and Peru. A few other *R* alleles of miscellaneous origin also were included in the test.

The foundation, colored aleurone stocks were of course extremely diverse in kernel and plant type. Before testing for paramutability in R^{st} heterozygotes the various *R* factors were introduced into the W22 inbred line, first by crossing the new strains with the latter stock, and then backcrossing the colored segregates to W22 $r^r r^r$ or W22 $r^g r^g$ recurrently. The proportion of background inheritance attributable to the exotic strains in the $R^r R^{st}$ and $R^g R^{st}$ plants eventually tested for paramutation in crosses on $r^g r^g$ plants was reduced in this way to about $\frac{1}{32}$.

The results of the tests for paramutability may be summarized briefly. Among R^r alleles of different geographic origins all but one, the single sample from Ecuador, were sensitive to paramutation in heterozygotes with stippled. Similarly, among R^g alleles from diverse sources, all but the three from Bolivia and Peru were paramutable. R^r-Cornell, an allele extensively used in genetic studies in the United States, and R^{rh} (colored aleurone, cherry pericarp in the presence of *P1*) were included in the paramutable group. Many of the R^r and R^g factors were sensitive to paramutation in about the same degree as standard R^r. Others were less sensitive, whereas a few alleles gave positive, but variable, reactions from plant to plant.

The general conclusion to be drawn from this experiment is that paramutable R^r and R^g alleles are widespread in maize.

Colored aleurone strains native to Bolivia, Ecuador, and Peru may be exceptional in this respect. The paramutagenic alleles, stippled and marbled, appear to be limited in distribution to these countries, and all self-colored mutants from them, of which 78 have been tested, have been found to be uniformly non-paramutable also. The significance of these facts is unknown.

EFFECTS ON R^r OF CERTAIN STRUCTURAL CHANGES IN THE LONG ARM OF CHROMOSOME 10

Three reciprocal translocations involving breaks in the long arm of chromosome 10 have been found to exert effects on R^r that tend to persist after the allele is returned by crossing over to a structurally normal chromosome. One effect is an enhancement of R^r pigment-producing action; the other is a decrease in sensitivity of R^r to paramutation in heterozygotes with stippled. Analysis of these phenomena is incomplete but, since the available facts disclose an important new aspect of the paramutation problem, they will be briefly summarized.

The reciprocal translocations used, and the chromosome breakage points in terms of relative distance from the centromere, as given by Longley (1958) are as follows: T2-10a (2L.17 and 10L.53), T4-10b (4L.18 and 10L.57), T9-10a (9L.14 and 10L.92). Position of the *R* locus has not been precisely determined, but it is between .57 and .92, and may not be far from .7. Thus the first two reciprocal translocations involve breaks proximal to *R*, whereas in the third case the break is distal to *R*. It will be noted that the breakage points in chromosome 10 are distant from the *R* locus by amounts varying from about $\frac{1}{10}$ to $\frac{1}{5}$ of the arm length. T2-10a and T4-10b each show about 9 per cent recombination and T9-10a about 5 per cent recombination, with the *R* locus. The three reciprocal translocations give normal development and fertility as homozygotes.

The studies involving the T2-10a and T4-10b reciprocal translocations were carried out in cooperation with Dr. Margaret Blackwood, and those on T9-10a with Dr. N. K. Notani.

Even though the break in chromosome 10 is distal to R^r in one case, and proximal in each of the others, the experimental results for the three reciprocal translocations are in agreement in their

main features and in so far as common tests were made. Except where stated otherwise, stock cultures in which standard R^r and the translocation (T) had been in coupling, and heterozygous for colorless aleurone (TR^r/r^r) for at least two generations, were used in the experiments. This fact is meaningful, as will be seen later.

The presently available data may be summarized as follows: (i) $R^rr^gr^g$ kernels resulting from the application to r^gr^g ♀ ♀ of pollen from either TR^r/r^r or TR^r/TR^r plants show a small, but statistically significant, enhancement of aleurone pigment formation, as compared with those from comparable testcrosses using R^rr^r or R^rR^r staminate parents. (ii) Enhancement does not occur when R^r/Tr^r plants are similarly tested. (iii) *Enhancement of R^r pigment-producing action is retained, at least in the generation immediately following, when R^r is returned to a structurally normal chromosome by crossing over in TR^r/r^r individuals.* (iv) T2-10a R^r gametes from T2-10a R^r/R^r plants have a lower pigment-producing potential, on the average, than T2-10a R^r gametes from T2-10a R^r/r^r sibs. (v) The testcross kernels from r^gr^g ♀ × T2-10a R^r/R^r ♂ matings tend to give bimodal distributions for aleurone pigmentation. The darker kernels, when subsequently grown out, yield a preponderance of semisterile, whereas the lighter kernels give a pronounced excess of fully fertile, plants. (vi) The results referred to in the two preceding items have been confirmed by repeating the experiments using T2-10a R^r/R^g and T2-10a R^r/r^r sib plants. The R^g allele employed was a mutant from standard R^r, indistinguishable from the latter except that it conditions green, rather than red, seedlings. (vii) The immediately resulting T2-10a R^r/r^r (crossover) offspring from T2-10a r^r/R^r × r^rr^r matings, when testcrossed on r^gr^g ♀ ♀, do not yield $R^rr^gr^g$ kernels exhibiting enhanced aleurone pigmentation, in contrast to T2-10a R^r/r^r plants from stock cultures in which T and R^r have been in coupling for at least two generations.

The effect of the reciprocal translocations on paramutation in heterozygotes with stippled will next be summarized. (i) Testcrosses on r^gr^g ♀ ♀ of TR^r/R^{st} plants, resulting from crosses between TR^r/r^r and $R^{st}R^{st}$ stock cultures, show that R^r carried by a T chromosome is relatively insensitive to paramutation. Such $R^rr^gr^g$ testcross kernels usually are much more heavily pigmented than those arising from r^gr^g ♀ × R^rR^{st} ♂ matings. (ii) *R^r retains its comparative insensitivity to paramutation in heterozygotes with stippled for at least one generation following return by crossing over from a translocated to a structurally normal chromosome.* (iii) There is a pronounced increase in sensitivity of R^r to paramutation in the TR^r/R^{st} offspring from TR^r/R^r (or TR^r/R^g) × $R^{st}R^{st}$ matings, as compared with R^r from a TR^r/r^r stock culture plant, similarly tested. (iv) The paramutagenic action of R^{st} differs only slightly, if at all, in R^r/TR^{st} and R^rR^{st} plants. (v) The R^r allele is comparatively insensitive to paramutation in TR^r/TR^{st} structural homozygotes.

Evidence came to light during the course of the experiments just recounted for another variable affecting R^r action that had not been suspected previously. It was observed that the $R^rr^gr^g$ kernels from testcrosses on r^gr^g ♀ ♀ of R^rr^r plants were slightly darker, on the average, than those from otherwise comparable r^gr^g ♀ × R^rR^r ♂ matings. The difference was close to the level that can be resolved by the operating procedures in use, and awaits verification. Likelihood that the difference is real, even if small, is suggested by the fact, mentioned earlier, that standard R^r in coupling with a translocation (TR^r) differs in pigment-producing action and in sensitivity to paramutation in TR^r/R^{st} heterozygotes, depending upon whether TR^r is derived from a TR^r/r^r stock culture or from TR^r/R^r progeny of a cross between TR^r/r^r and R^rR^r stock cultures. Insertion of R^r into a T chromosome, and maintenance of the stock in the TR^r/r^r heterozygous combination may merely exaggerate an effect that is already present, but at a much lower level, in structurally normal R^rr^r plants. No difference is detectable in paramutability in R^rR^{st} heterozygotes, of R^r alleles extracted from R^rr^r and R^rR^r plants. The pigment-producing action of R^r in the testcross offspring is greatly reduced in both cases. Conceivably, however, if an allele less strongly paramutagenic than stippled were used for the test a difference in reaction of R^r from the two sources might be demonstrable.

Reality of the effects of the T2-10a, T4-10b, and T9-10a reciprocal translocations on both enhancement of R^r pigment-producing action and sensitivity to paramutation in TR^r/R^{st} heterozygotes is unmistakable. The extent, however, to which these responses are conditioned by heterozygosity for the r^r allele in TR^r/r^r plants (or by the fact that R^r is present in single, rather than double, dose) remains to be determined. The latter problem illustrates in a rather subtle way the principle

that in paramutation studies both genotype and "genotypic history" are essential considerations.

The earlier investigations on R^r paramutation disclosed only the effects on R^r action of factors situated at the same level in the homologous chromosome. It is now apparent that the phenomenon must be viewed in broader terms. The translocation studies show that the reactivity of R^r is markedly influenced also by structural rearrangements in the long arm of chromosome 10, either proximal or distal to the R locus and remote from the latter. These changes are detectable, however, only after a lag of undetermined length following establishment of the new spatial relationships.

Persistence of the translocation effects for at least one generation following return of the allele by crossing over to a structurally normal chromosome indicates that, whereas the inciting chromosome breaks are distant from R^r, heritable changes are registered at, or near, the R locus itself. The meaning of this regional influence is obscure, but the evidence raises again the question whether there are functional components of the chromosome much larger than individual loci. Lima-de-Faria (1956) has critically reviewed the data showing that interactions occur between chromosome regions that are manifested in various ways at the chromosome level. The present findings suggest that where sufficiently sensitive systems are studied such interactions may be detected in the phenotype of the organism as well.

EFFECT OF ABNORMAL CHROMOSOME 10 ON PARAMUTABILITY OF R^r

The standard R^r allele, after insertion by crossing over into a chromosome 10 carrying a large heterochromatic knob (K) near the end of the long arm, but showing only about one per cent recombination with R, is found to be relatively insensitive to paramutation in heterozygotes with R^{st} or R^{mb}.

The abnormal chromosome 10 in question, which Rhoades (1952) reported as occurring in a number of maize strains from Latin America and the southwestern United States, has been found by Rhoades and by Longley (1945) to exert various pronounced cytological and genetic effects. These effects, which have been further analyzed recently by Emmerling (1959) and Kikudome (1959), include preferential assortment of the K-carrying chromosome in K10/10 plants at megasporogenesis, and a large reduction in frequency of crossing over in the region distal to the R locus. Abnormal chromosome 10 also interacts with certain knob-carrying chromosomes 9 to increase the incidence of crossing over in the latter. The writer has observed that K10, in homozygous condition, but not in K10/10 plants, markedly exaggerates the tendency of the W22 inbred line to form zigzag stems, and also reduces ear weight to about 60 per cent of the normal value.

Insertion of standard R^r into abnormal chromosome 10, has little or no effect on the aleurone pigment-producing action of R^r, as such. That is to say, testcrosses on $r^g r^g$ ♀ ♀ of R^rK/r^g and R^rr^g plants yield colored kernels with about the same grade of mottling. Comparison of the results of mating of $R^r/R^{st}K$ and R^rR^{st} plants on $r^g r^g$ ♀ ♀ indicates that K in coupling with stippled ($R^{st}K$) may reduce somewhat the paramutagenic action of the R^{st} allele. The observed difference was slight in one of two families tested, and only moderate in the other. Standard R^r, however, is comparatively insensitive to paramutation in $R^rK/R^{st}K$ plants and, as Weyers (1959) has observed, in R^rK/R^{mb} individuals also. The levels of pigmentation of the $R^rr^gr^g$ kernels on many of the testcross ears in these cases were as high as those resulting from $r^g r^g$ ♀ × R^rr^g ♂ control matings. Weyers (1959) tested an R^r allele extracted by crossing over from an R^rK chromosome, and found it to be normally paramutable in a marbled heterozygote (R^rR^{mb}). So far as may be judged from this single instance, the insensitivity of R^r to paramutation in the R^rK combination does not persist after R^r is removed from abnormal chromosome 10.

PARAMUTATION IN OTHER ORGANISMS

Evidence is at hand showing that paramutation occurs in a variety of organisms. Coe (1958) has reported a second case in maize, at the B locus; and Hagemann (1958) has observed genetic change of this kind in *Lycopersicon*. Renner's (1937, 1959) studies on the *cruciata* character in *Oenothera*, extending over many years, doubtless were concerned with the same phenomenon, which he called "somatic conversion." Unequivocal establishment of paramutation in this instance, however, was difficult because of the unusually complex nature of the *Oenothera* material. In studies on the "labile" factor laciniata (*lac*) and a mutant from it, termed normal-2 (no^2), in *Malva parviflora*, Lilienfeld (1929) distinguished between "homostatic" zygotes, lac/lac and no^2/no^2, and the "hetero-

static" zygote, *lac*/*no*^{2}, on the grounds that the respective alleles in the former were relatively stable in somatic tissue, whereas the *lac* allele in the heterozygote was transformed progressively into the *no*^{2} form, as development of the plant proceeded. A still earlier example of what is here termed paramutation is afforded by Brotherton's (1923) analysis of "rogue" type in the garden pea. The factor *x* of the Gradus variety was observed to mutate rarely to the *X* factor for Gradus rogue. The two homozygotes, *XX* and *xx*, are relatively stable. The *x* factor in *Xx* plants, however, is very unstable, and mutates to *X* with such high frequency that F_1 hybrids between *XX* and *xx* may change to the *XX* condition, and then produce only the rogue class of gametes. Brotherton termed this process "mass mutation."

An especially well analyzed example of paramutation is afforded by the segregation-distorter locus, *SD*, in, or near, the centromeric heterochromatin in chromosome 2 of *Drosophila melanogaster*, recently reported by Sandler and Hiraizumi (1959). Noujdin (1944) reported that in *D. melanogaster* the mosaic expression of the closely linked genes yellow and achaete was influenced by structural homozygosity and heterozygosity for the nearby scute-8 inversion, and that the effects so induced persisted for a few generations. Cytological evidence for corresponding changes in "heterochromatization" of the affected region was found by Prokofyeva-Belgovskaya (1948).

The occurrence of paramutation in an insect as well as in several flowering plants suggests that the phenomenon is coextensive with chromosomal heredity.

PERSISTENT INTRACHROMOSOMAL RESPONSES TO THE CELLULAR ENVIRONMENT

Two salient facts which emerge from the paramutation studies are of significance for a theory of chromosome organization. The first is that there is present at, or very near, the *R* locus a factor, widely distributed in *Zea mays*, which invariably undergoes genetically detectable change in response to (a) presence in the same nucleus of a particular other factor, presumably of the same functional class, at the corresponding level in the homologous chromosome, or (b) different structural rearrangements involving the chromosome arm in which *R* is situated. The second fact is that, so far as the evidence goes, these factors are qualitatively distinct from the fundamental pigment-producing components of the *R* locus. The assumed duality in organization of the *R* region, referred to at the beginning of this article, rests upon this point.

There is evidence from mutable loci also for such bipartite structure of a highly localized chromosome segment, as McClintock (1951) first proved in the case of Activator (*Ac*) and Dissociation (*Ds*) in maize. Variegated pericarp, with which the writer and his students have worked, provides another example. The variegated allele comprises two elements, P^{rr}, a gene for self-red pericarp and cob color, and Modulator (*Mp*), which when conjoined with P^{rr}, suppresses the pigment-producing action of the latter. *Mp* and *Ac*, although discovered independently, are probably the same factor. The colorless allele, consisting of the $P^{rr}Mp$ combination at the *P* locus, is unstable, and mutates frequently and irregularly in somatic cells to red, yielding the collective, variegated pericarp phenotype. The mutation involves transposition of *Mp* away from the *P* locus, usually to one or another position nearby in the same chromosome (Van Schaik and Brink, 1959). Orton (1960), in our laboratory, has recently shown that the rarely occurring reverse mutations of self-red (derived from variegated) to variegated pericarp consist in transposition of the previously transposed *Mp* factor back to the *P* locus, and that the frequency of this event is a function of proximity in the same chromosome of the transposed *Mp* to *P*. Such reverse mutations do not occur in mutant red-eared plants lacking a transposed *Mp* unit.

It is generally assumed that the hereditary substance is genetically unaltered during differentiation and development of the organism. Mendelian doctrine, however, does not demand that all the germinal material be stable during ontogeny, as Morgan (1934), for example, pointed out when he wrote, "The visible differentiation of the embryonic cells takes place in the cytoplasm. The most common genetic assumption is that the genes remain the same throughout this time. It is, however, conceivable that the genes are building up more and more, or are changing in some way, as development proceeds in response to that part of the protoplasm in which they come to lie, and that these changes have a reciprocal influence on the protoplasm. . . . If the latter (protoplasm) can change its differentiation in a new environment without losing its fundamental properties, why not

the genes also? This question is clearly beyond the range of present evidence, but as a possibility it need not be rejected."

This idea, long in abeyance, gains considerable credence from recent work of two kinds. Briggs and King (1959) found that, in frog embryos, nuclei transplanted from late gastrula cells to enucleated eggs show particular changes in capacity to control differentiation that are not reversed following subsequent serial transfers. Likewise, Moore (1958) has shown that *Rana pipiens* egg nuclei introduced into, and allowed to undergo repeated division in, *R. sylvatica* cytoplasm lose the capacity to sustain embryo development following return to enucleated *R. pipiens* ova. Significant in this connection also are the transformations observable in polytene chromosomes during larval development in Diptera (for recent reviews see Beermann (1956) and Pavan (1959)). Pronounced growth, in the form of "puffs," occurs in specific chromosome bands at particular larval stages, associated with the formation of large amounts of RNA which is later released into the nuclear sap. The puffed region then regresses, and may return to the typical banded condition. Noteworthy facts emerging from the experiments of Pavan and his associates are (i) that a disproportionate increase of DNA in the affected region, as compared with neighboring bands, may occur during the puffing process, an observation confirmed by Rudkin and Corlette (1957) and (ii) the conspicuously heterochromatic regions are differentially active in the formation of DNA at numerous stages in larval development.

These observations provide direct evidence for specifically localized chromosomal changes synchronized with larval development, and suggest also that heterochromatin plays a special role in the process. Evidence that particular chromosome segments vary in form in different tissues has been adduced also in the flowering plant, *Ornithogalum virens* (Lima-de-Faria, Sarvella, and Morris (1958)). Presumably, the proximate relationship of the genonema to differentiation and development of the organism is a unique phenomenon in cellular physiology. It is a major step forward to have gained clues to the nature of the events at this level.

Metz (1927) and Smith-Stocking (1936) have reported a striking case in *Sciara coprophila* of functional differentiation between homologous chromosomes of maternal and paternal origin that is of interest for the paramutation phenomenon. These investigators showed that, whereas chromosome assortment at meiosis was conventional at oogenesis, the chromosomes retained in the functional cell at the monocentric first spermatocyte division invariably were those derived from the mother.

There is substantial genetic evidence from mutable loci in flowering plants also for the occurrence of persisting chromosomal changes arising in somatic cells in response to varying environmental conditions, both within and external to the organism. These changes are verifiable as genetic in nature if they take place in a cell lineage from which spores eventually are formed. An example, chosen from among the several that could be cited because of the writer's familiarity with similar material, will be used for illustrative purposes.

Eyster (1926) found that the frequency of mutation of variegated pericarp to stable self-color in maize was markedly influenced by the environmental conditions under which the plants were grown. Random samples of seed from each of eight variegated ears were grown out in (i) a cool, moist, coastal region in California, and in (ii) an arid portion of Arizona with very high day and comparatively low night temperatures. The frequency of red sectors covering one-quarter kernel, or more, was higher throughout in the California than in the Arizona crop. The red sectors on variegated ears, as pointed out above, are now known to result from transpositions of Modulator from the *P* locus to various other chromosomal sites. It is evident that this process, involving heritable change within the chromosome, is more or less readily responsive to alteration in the external environment of the plant.

The frequency of transposition of Modulator from the *P* locus likewise varies according to the internal environment of the individual. Anderson and Eyster (1928) demonstrated that the number of mutations of variegated to red in a medium variegated maize strain rises much faster, as development of the ear shoot proceeds, than can be accounted for in terms of cell number. This result is explainable on the assumption that the Modulator component of the variegated allele is much more sensitive to transposition in the cellular substrates existing at the later stages of ear development than in those occurring earlier.

Similarly, the markedly reduced frequencies of mutation of variegated pericarp to self-red as the

number of transposed Modulators in the genome is increased from zero, as in medium variegated, to two, as in very light variegated (Brink, 1954) may be regarded as reflecting stabilization, by interaction of the *Mp* units present, of the *Mp* component of the variegated allele against transposition in a progressively wider range of cellular environments.

McClintock (1951, 1956) has interpreted the changing frequencies of mutation of unstable alleles as development of the individual progresses in a different way. She assumes that these variations reflect the operation of a system of chromosomal elements, termed controllers, that regulate timing of the mutations in an absolute sense. McClintock's investigations led to the postulate that the chromosome comprises two primary classes of self-replicating components, termed genes and controllers. The gene embodies a certain action potential for the locus, and controllers predetermine how and at what time this potentiality is expressed during development. The controllers, which are assumed to be associated with heterochromatin, and are organized in systems that pervade the chromosomes, influence development by effecting an orderly sequence of triggering responses at the numerous loci whereby the gene, in a given instance, is made active at one level or another, or becomes inactive. The implication of this hypothesis is that the various loci are progressively activated during development of the individual by controllers functioning in genetically fixed ways and in a predetermined sequence.

The experimental evidence concerning unstable loci in maize on which McClintock based this view need not be interpreted, however, in terms of chromosome elements acting as an independent timing mechanism. One can, in fact, turn McClintock's controller argument around, without compromising the facts, and assume that what she considers primary causes are, themselves, effects. The orderliness, relative to the ontogenetic cycle, with which mutations at unstable loci sometimes occur, emphasized by Demerec (1931), McClintock (1951), and others, is a most significant fact from the standpoint of relating persisting intrachromosomal changes to development of the organism. The question at issue is whether this orderliness reflects a system of interacting chromosomal elements operating autonomously and in a predetermined manner to control timing of the mutations in an absolute sense, as McClintock supposes, or is basically the result of statistically regular responses of the interdependent loci concerned, as a result of differential sensitivity of the latter to the cellular substrates successively presented as differentiation and development of the organism proceeds. In the writer's view, the data from mutable alleles favor the latter interpretation without, of course, precluding interactions of various sorts, including sequential effects, among chromosome components as important variables also. Furthermore, the embryological evidence shows that it is the hierarchy of structures evolved during ontogeny that determines, in an overriding way, the manner in which the genetic endowment is expressed at each stage, not the other way around. The point it is desired to emphasize is that what McClintock refers to as "timing" variations in the operation of supposedly autonomous intrachromosomal controller systems are here construed as responses, in the first instance, of particular chromosome elements to cytoplasmic substrate changes which pace the intrachromosomal changes throughout development of the organism.

T. Van Schaik (1955) obtained data bearing on this question from variegated pericarp in maize. Plants were reared of four inbred strains, carrying a common variegated allele, and of the six possible single crosses between these lines. The F_1 hybrids were divided into two sets, one of which was grown under favorable conditions, and the other in very dense stands nearby on comparatively infertile soil, so that at maturity the plants scarcely exceeded the normally grown inbreds in height and ear size. The artificially dwarfed F_1 hybrids gave a mutation rate of variegated to self-red of 25.7 per 1000 kernels, as compared with 48.2 per 1000 kernels for their normally grown, vigorous counterparts. The corresponding average value for the parental lines was 42.3 per 1000 kernels. Since the genotypes of the two sets of hybrid plants were identical, and development was nearly synchronous throughout, it is clear that the approximately 47 per cent reduction in mutation rate in the artificially dwarfed material was a response of the Modulator transposition process to the cellular substrates associated with partial starvation of the plants.

The fact that some unstable alleles undergo heritable change almost exclusively in particular tissues also points to the conclusion that stability is a function of the cellular substrate. The stippled allele in maize is a case in point. Each of the 50 to 90 usually small and irregularly distributed

patches of colored cells in a stippled endosperm is assumed to represent a mutation of the stippled allele to self-color, on the grounds that if a continuously colored area encompasses an entire kernel, as occasionally occurs, then transmission of self-color to the offspring is demonstrable. Thus the R^{st} factor is extremely sensitive to mutation in this tissue. The rarity of clusters of self-colored kernels on stippled ears, on the other hand, shows that stippled is highly stable in the somatic tissues of the plant. Among 83 self-colored mutants found among 44,519 seeds on $R^{st}R^{st}$ plants, for example, all were distributed on the parent ears as single kernels (Ashman, 1960). Clusters of self-colored mutant kernels on R^{st} heterozygotes, however, have been observed in a few cases. For instance, among 754 R^rR^{st} and R^gR^{st} plants, tested for another purpose, four bore R^{st}-R^{nj} chimera ears. It is evident that the stippled allele, although very unstable in the endosperm, rarely mutates in the somatic tissues of the plant. This case is but another example of a phenomenon that has become well known since Demerec (1941) showed that certain unstable alleles in *Drosophila virilis* varied widely in stability in different tissues, and at different stages of ontogeny.

Differential sensitivity to heritable change in varying cellular environments must be considered one of the characteristic features of unstable loci.

SIGNIFICANCE FOR CHROMOSOME ORGANIZATION

At this stage a framework of ideas intended to relate the data concerning paramutation and mutable alleles to chromosome organization must necessarily be a loose structure. The facts are few, and the connections between them often are not apparent. Any comprehensive working hypothesis that is formulated will entirely lack validation at one or more important points. What it is proposed to do here, therefore, is to set up a chromosome model, admittedly conjectural in various respects, with the lesser aim of defining, as sharply as may be, the direction in which the data on paramutation and mutable loci seem to point. Where to probe for additional evidence likely to bring the general problem of chromosome organization and function into clearer perspective is the broader question to which the following, rather free-ranging, speculations are addressed.

The point of departure in the scheme to be developed is the fact that at the *R* locus (or in the immediate *R* region) in maize two classes of heritable variations occur, mutations and paramutations. As stated earlier, the mutations are sporadic, step-wise, undirected, and stable. Paramutations, on the other hand, occur invariably in certain heterozygotes, and so are directed; the new forms are metastable, and constitute a graded series in terms of level of action. Similarly, there is proof for a two-fold basis of variation at certain mutable loci in maize, variegated pericarp being one of the established examples.

It is inferred from the evidence for duality of make-up in the two cases that the peculiar genetic phenomena associated with mutable loci and the *R* locus, as reviewed here, are only different expressions of a common class of chromosome constituents. Indeed, these particular expressions may well prove to be limited, and not even representative, segments of a much wider spectrum of phenomena which these chromosome materials underlie (see later). A generic term is needed to apply to the entire range of such intrachromosomal alterations. It is proposed to extend use of the term "paramutation" for this purpose. Accordingly, the particular changes that R^r undergoes in R^rR^{st} plants, for example, are now considered as a sub-class within the wider category of paramutations in general.

Numerous tests show that paramutation at unstable loci, in contrast to mutation in general, is extraordinarily sensitive to the changing internal milieu as differentiation and development of the organism proceed, and to external conditions. This is construed to mean that the two kinds of components making up the genonema possess quite different properties and serve unlike functions.

The above facts provide a base for the hypothetical model of chromosome organization that will now be outlined. (i) The chromosome comprises two substances, orthochromatin and parachromatin, that pervade the genome, in intimate association with each other. This assumption is in accord with the fact that two kinds, or forms, of chromatin, called euchromatin and heterochromatin, are recognizable, although not definitively, by certain cytological and genetical criteria (Lewis, 1950; Hannah, 1951). Orthochromatin and parachromatin may prove to coincide with these materials, although not as the latter are now characterized. The new terms are employed because it is desired to avoid certain preconceptions associated with the word heterochromatin, particularly the idea that, because the substance often occurs in large

blocks, this is necessarily the most important factor in its distribution. (ii) Orthochromatin embodies the DNA templates controlling formation of the numerous enzymes involved in the more specific processes of protein synthesis, and is very highly differentiated. It is the genetic substance proper, that varies by mutation, and whose composition and architecture are disclosed by conventional Mendelian analysis. (iii) Parachromatin is self-replicating, and co-extensive in distribution with orthochromatin. It is assumed to condition the intrachromosomal processes involved in the functional differentiation of the several loci by undergoing paramutation, in an orderly way, in response to the changing cellular environments of the developing organism. Parachromatin is relatively homogeneous, although not homologous, throughout the genome, in accordance with its general function of activating the orthochromatin. It may further be supposed that parachromatin normally is unresponsive to the ordinary vicissitudes of the protoplast, but is nicely tuned to react only to the particular extrachromosomal stimuli that define, more or less specifically, the developmental progression. The specificity and regularity with which a particular reaction of parachromatin to an extrachromosomal stimulus is evoked may be considered comparable to that whereby R^r invariably is changed to $R^{r'}$ in response to the presence of R^{st}, but not of a nonparamutagenic allele, in the same nucleus. Whereas orthochromatin remains qualitatively constant in all nuclei of the individual, parachromatin is altered by accretion, diminution, and in other ways, in accordance with the cellular substrates that evolve during ontogeny. The parachromatin thus takes on a succession of potentially reversible, but mitotically transmissible states, reflecting progressively the ontogenetic history of the cells through which it passes. It is the nexus between chromosomal heredity and development of the organism. Included in the states that parachromatin can assume is the ground condition characteristic of gamete nuclei. Ultimate reduction of the parachromatin from a differentiated state to this level may be one of the functions associated with meiosis. (iv) A distinction is to be made between the genesis of parachromatin and parachromatin itself. Parachromatin is assumed to be a product of a special class of chromosome elements (Muller and Gershenson, 1935) that might be called determinants of communication. It is elaborated by these determinants in response to the cellular environment. This leads to the suggestion that parachromatin is genetically ambivalent. The substance is ultimately dependent for continuity on a special class of gametically transmissible factors which, like orthochromatin, are defined by DNA nucleotide sequences. As a product of these determinants in somatic cells, however, it is capable of replicating in phase with orthochromatin and then functions as quasi-genetic material. Since parachromatin effecus communication between orthochromatin and the nuclear metabolic pool, its ultimate role is epigenetic. The substance may be pictured, therefore, as the meeting ground of the genetic and epigenetic functions of the chromosome.

According to this reasoning, the chromosome operates as an information exchange during differentiation and development of the organism. One essential constituent, the orthochromatin, maintains its integrity throughout, and defines content of the outgoing messages during ontogeny. The other essential component, the parachromatin, is sensitive and specifically responsive to the cellular environment. The parachromatin, as such, receives, records, and mitotically transmits from cell to cell, information from outside the chromosome. These processes are effected in such a way as to elicit specific responses in the orthochromatin. These responses then become the outgoing messages to the cell. Thus, the orthochromatic elements are not open terms during ontogeny, but are conditioned to react, as development proceeds, by orderly changes in parachromatin. These orderly changes in somatic nuclei are the normal expression of the paramutation process.

The unusual behavior of the R^r allele in maize plants heterozygous for stippled, and the data on mutable alleles, are comprehensible in terms of the paramutation concept, provided an additional assumption is made, namely, that these phenomena reflect paramutations that are somatically irreparable and, hence, simulate mutations in that they are passed on through germ cells to the offspring. Such loci conform neither to the rigorous rules of heredity nor to the orderly requirements of development, but reflect both in bizarre ways. Their behavior may be attributed, therefore, to chromosomal alterations of abnormal kinds at interfaces between orthochromatin and parachromatin. These changes disturb development because the affected locus is more or less blocked

from the action of the cellular stimuli to which it would normally respond by means of a specific, and conformable, parachromatin arrangement. They are hereditary in an irregular way because they often transcend the capacity of the mechanism whereby paramutations are reversed during ontogeny, or at meiosis, in response to the changing cellular substrates. Accordingly, they tend to spill over into the gametes.

If the inferences drawn in the preceding paragraph are correct, then genetically unstable loci, as ordinarily encountered in maize, for example, have an important limitation for the study of paramutation when the latter is viewed as a process characteristic of, and normal to, somatic cells only. These gametically transmissible paramutations are mistakes that the somatic cell system can neither repair nor eliminate. This restriction would not apply, however, to what appear to be normally ordered paramutations at the variable-state loci described by Sonneborn (1954), Nanney (1958), and Lederberg and Iino (1956) in certain microorganisms.

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NEW BIOLOGICAL BOOKS

The aim of this department is to give the reader brief indications of the character, the content, and the value of new books in the various fields of Biology. In addition there will occasionally appear one longer critical review of a book of special significance. Authors and publishers of biological books should bear in mind that THE QUARTERLY REVIEW OF BIOLOGY *can notice in this department only such books as come to the office of the editor. The absence of a book, therefore, from the following and subsequent lists only means that we have not received it. All material for notice in this department should be addressed to H. B. Glass, Editor of* THE QUARTERLY REVIEW OF BIOLOGY, *Department of Biology, The Johns Hopkins University, Baltimore 18, Maryland, U. S. A.*

REVIEWS AND BRIEF NOTICES

Biology: History and Biography 138
The Young Naturalist 140
Ecology and Natural History 142
Evolution 144
Genetics and Cytology 146
General and Systematic Botany 148
Plant Physiology 148
Economic Botany 149
General and Systematic Zoology 151
Economic Zoology 155
Animal Morphology 155
Animal Physiology 156
Biophysics and General Physiology 161
Biochemistry 162
Microbiology 167
Health and Disease 172
Psychology and Animal Behavior 175
Human Biology 176
Biometry 177
De Omnibus Rebus et Quibusdam Aliis 177

BIOLOGY: HISTORY AND BIOGRAPHY

JUST BEFORE DARWIN. *Robert Chambers and VESTIGES.*

By Milton Millhauser. Wesleyan University Press, Middletown, Conn. $4.50. x + 246 pp.; ill. 1959.

One of the fruits of twentieth century historical scholarship, and particularly of the study of the history of ideas, is the discovery that ideas have an organic character. Like man, from whom they spring, ideas have ancestors; they are a product of fertilization, and conceived some time before they are born, must be carefully nurtured, begin to modify their environment only when they have reached a certain growth, and will survive only if they can adapt to or change their environment. Is it surprising, then, that this presumption of an organic analogue for the idea has come to be accepted in a time when the evolutionary currents in Western thought have become sufficiently stabilized for us to see how they might be usefully diverted into other channels? Viewed in this light, the study of the history of ideas itself becomes, by an interesting involution, a phenomenon in the history of ideas.

Just Before Darwin, perhaps unfortunately, suffers as a book from a lack of the organic unity it might have had if it were purely a study of ideas. Because of its digressive nature, a sketch of the contents is necessary. The book examines a series of themes centering about or involving Chambers' *Vestiges of the Natural History of Creation*, as the full title reads. It includes a short biography of Chambers, a sketch of the history of English geology before 1844 (the date of the first edition of the *Vestiges*), a similar sketch of the history of English and Continental biology, a critical examination of the *Vestiges* itself, a survey of reactions (chiefly of Anglicans and English Protestants) to the book, an examination of Chambers' several revisions, and finally a sketch of the influence of the book on Chambers' own life. There is also an elaborate bibliography (29 pp.), relevant to each of the sections of the book, to every aspect of Chambers and the *Vestiges*, and to its literary influences—Millhauser being a professor of English.

One of the more interesting theses in Millhauser's work involves the problem of explaining the violent reaction which evolutionary concepts met with, particularly in 19th century England. The traditional explanation in history textbooks, that everyone believed, *de fide*, that God had dictated the *Bible* so as to correspond with the chronology of Bishop Ussher, seems to suffer from naiveté. Catholic theologians in general, for example, reacted rather mildly to evolutionary concepts: Newman, as Mill-

hauser points out, was condemned along with Comte and *Vestiges* for adhering to a principle of historical development.

While accepting the importance of the religious basis for the reaction, Millhauser also points out that the educated Englishman of the early 19th century was essentially the product of a classical education intended to produce the man of letters, and hence not scientifically oriented. Chambers himself, Millhauser emphasizes, was just such a man of letters: a literary scholar and editor, and one who approached science (to his own detriment in the *Vestiges*) with too much of a scholar's reliance on the written word. Hence, Millhauser suggests, the literate Englishman of 1844, or even later, was in general not intellectually prepared to accept the obvious implications of the newly discovered mass of brute facts of geology and biology, especially if these facts implied theories which conflicted violently with the presuppositions of his classical education. What Millhauser does not investigate, but which would be worth-while knowing, is how much influence the preoccupation with certain classic authors, and the exclusion of others, reinforced this intellectual provincialism of the 19th century literate Englishman. Schopenhauer, for example, in his *Zur Philosophie und Wissenschaft der Natur*, refers to his English contemporaries as being in a state of "indifference and complete barbarism with respect to all speculative philosophy," and characterizes the "English parsons" as "those slyest of all obscurantists."

Despite the fact that *Just Before Darwin* is based on a doctoral dissertation, it has a readable and urbane style. If the work suffers from diffuseness, apparently caused by the dissertational obsession with the idea that everything, however relevant, must at least be mentioned, the very scholarship of the book makes it valuable to the student of 19th century evolutionary thought.

JAMES J. HILL

THE LIFE AND LETTERS OF CHARLES DARWIN. *Including an Autobiographical Chapter. Volumes I and II.*

Edited by Francis Darwin; foreword by George Gaylord Simpson. Basic Books, New York. $10.00 (the set). Vol. I, xxii + 558 pp., ill; Vol. II, viii + 562 pp; ill. 1959.

This collection of letters written by the founder of the theory of organic evolution, with editorial comments by his son, Francis, was first published in 1888. Its present reprinting coincided with the sesquicentennial of Charles Darwin's birth as well as with the centennial of the publication of his epochal book, *On the Origin of Species*. This constitutes an important item of Darwiniana. For, as George Gaylord Simpson notes in his appreciative Foreword, "The essentials of what is known about Darwin's personality are in the present work." Its republication therefore is to be welcomed.

W. L. STRAUS, JR.

JAN EVANGELISTA PURKYNĚ. *Czech Scientist and patriot. 1787–1869.*

By Henry J. John. The American Philosophical Society, Philadelphia. $3.00. xii + 94 pp.; ill. 1959.

Purkyně is better known to us by the German form of his name that he used in his publications: Purkinje. H. J. John has written this book with the purpose of popularizing the details of Purkyně's life. In this he has succeeded elegantly. However, he has not neglected the research for which Purkyně is justly celebrated. In addition to the account of his work in the text, the English translations of several of his papers are reproduced in the appendices. There is also a complete bibliography of his publications. Anyone interested in Purkyně will do well to study this monograph.

MYRON L. WOLBARSHT

ZULU JOURNAL. *Field Notes of a Naturalist in South Africa.*

By Raymond B. Cowles. University of California Press, Berkely and Los Angeles. $6.00. xiv + 267 pp.; ill. 1959.

In the summer of 1950 the author of this book and I lay half out of our sleeping bags listening to the sounds of night on the Chupadera Mesa of New Mexico. He remarked at the time that the low growing pinyon pines, junipers, grassland, and great billowing thunderheads of the afternoons took him back to his native Natal. His ear caught the twittering sound of birds passing overhead in the black night. He said "Snowy plovers," and the beam of his flashlight soon picked out the stark white of the swiftly passing birds.

Two things in this vignette have marked Cowles' thinking and writing throughout the years I have known him, and both are keynotes in the fine book being reviewed here. First, a constant comparison of the phenomena of his present-day world with the bright days he spent as a youth wandering, wondering, and looking with boyish curiosity at untrammeled Africa; and second, his unusual ability to take in the scene around him with every sense at his command. He hears the sounds that fail to penetrate to the more pedestrian, and he takes in the colors of the grass, the sparkle of insect wings, and a thousand other delights that most of us seldom see. These things he has captured in a fluid

prose, such as is too seldom written by the naturalist.

His book begins with his birth in the Natal summer of 1896, the son of a pioneer missionary family, and progresses through a potpourri of incidents and observations that, taken together, paint a vivid picture of this now-vanished way of life. He tells of many species of African birds and their intricate lives, of the remarkable behavior of termites, of larger game, and of the lives and superstitions of the Zulus. The author then switches to his observations upon his return to Natal after almost thirty years' absence. The comparison with the old days of his youth is, in many ways, an unhappy one. The inroads of civilization could be seen in a thousand subtle and not so subtle ways. I suspect that this sort of comparison would probably hold true for nearly anyone who left his native heath and returned after so long an absence. Things would have changed, and many of the changes would displease us. This displeasure would most likely stem from some measure of reality, on one hand, and on the other, of the sense of youth passed, its strong emotions hard to find, and its wonder at tiny discoveries dulled into a more worldly adulthood.

Cowles' dismay at seeing the soil denuded, animals being forced out by the advance of civilization, and a decay in the living standards of his Zulu friends, is no fiction of memory. It is one example of the central fact that a biologist must face in this modern world, wherever civilization can maintain a foothold. No serious student of nature can deny that we are spending our capital of natural resources at an already furious, yet ever-increasing rate, linked directly to an exploding population. Natal is but one unhappy focal point of this pervasive fact.

The final chapter of the book is an eloquent indictment of the folly of the present course of human events in South Africa. The ultimate endpoint, as Cowles sees it, is a steady worsening of the black man's lot as population pressures increase, with the already great gulf between black and white probably reaching the explosion point in the not too distant future. Since the whites have farsightedly set up the almost unique game preserve systems that today harbor the major game herds, and since they have not so farsightedly omitted the the blacks from their management, the precious game herds will go if black Africa struggles to its feet in a bloody revolt. The protein-starved millions will simply engulf the irretrievable wildlife in the midst of the upheaval.

The crux of the problem, of course, is the birth rate, which is no longer balanced by an equally effective death rate. Disease control, in part brought by Cowles' own missionary relatives, and other life-preserving features of modern civilization, have unleashed man's powerful reproductive potential, now unchecked. The day must come, however, when this explosion will stop. In its present course it will cease only when miserable, crowded, resourceless human beings force it to a halt by their very numbers. Values such as those Cowles describes with such sensitivity will be irretrievably lost, in a world which the naturalist will find bitter indeed.

When I have seen Cowles among his eager young students of herpetology, of which I was one, one could sometimes hear him say: "Yes, it is fine that you have discovered a new species of lizard, but we biologists, have we time for this fun?"

KENNETH S. NORRIS

THE YOUNG NATURALIST

ALL ABOUT THE ICE AGE.

By Patricia Lauber; illustrated by John C. Wonsetler. Random House, New York. $1.95. viii + 151 pp.; ill. 1959.

This is science writing for youngsters at its best—exciting, informative, accurate, and clearly understandable. It is a safe bet too that few older people who get their hands on it will put it down permanently unread.

The subject matter is skilfully allowed to speak for itself in a way that captivates the reader. The tale begins with the epochal discovery of Louis Agassiz that glaciers move; and it ends with a discussion of the recent theory of Ewing and Donn about a possible relation between freezing and thawing of the Artic Ocean and our supposedly recurrent periods of glaciation. In between are stories of wooly mammoths in North America, snowflakes in Brazil, magnolias in Greenland, the International Geophysical Year expeditions to icy regions, and much more besides. This is a fact-filled book, yet one which never reads like a catalogue nor becomes dogmatic. Facts are suffused throughout with the scientific spirit of adventure in the search for meaning and the demand for firm evidence to support theories.

The book is embellished by a series of handsome photographs, mostly from I.G.Y. work on ice masses, and by the vigorous and well-chosen drawings of John Wonsetler. There is a useful index. The title, *All About the Ice Age*, is of course a misnomer but derives from the name of the series and can be dismissed as a cliché all will understand. Author, illustrator, and publisher are to be con-

gratulated for an outstanding work directed especially to junior high school children still at an age when attitudes can be influenced.

GAIRDNER MOMENT

FEATHERS AND FLIGHT.

By Clarence J. Hylander; drawings by the author. The Macmillan Company, New York. $3.95. x + 214 pp.; ill. 1959.

SEA AND SHORE.

By Clarence J. Hylander. The Macmillan Company, New York. $3.75. x + 242 pp.; ill. 1950.

TREES AND TRAILS.

By Clarence J. Hylander. The Macmillan Company, New York. $3.00. x + 237 pp.; ill. 1952.

ANIMALS IN ARMOR.

By Clarence J. Hylander. The Macmillan Company, New York. $3.75. xvi + 203 pp.; ill. 1958.

ANIMALS IN FUR.

By Clarence J. Hylander. The Macmillan Company, New York. $3.50. xii + 206 pp.; ill. 1956.

INSECTS ON PARADE.

By Clarence J. Hylander; drawings by the author. The Macmillan Company, New York. $3.75. xvi + 208 pp.; ill. 1957.

The author, currently a Visiting Professor of Biology at Bowdoin College, has written this series of books primarily for the young naturalist. *Feathers and Flight*, the most recent addition, completes this set of books which have appeared over a 10-year span. *Sea and Shore*, a beginner's marine biology, introduces the plants and animals living on the constantly changing seashore. Among the many vivid word pictures painted for the young reader are the beach at low tide, teeming with crawling and burrowing animals among the seaweeds and shell remains of coral, sponge, and sea urchins; and the tidal pool, a natural aquarium ornamented with barnacles and limpets and inhabited by periwinkles, starfish, and crabs. These are some of the fascinating hunting places suggested for the seashore naturalist.

Trees and Trails, describes the general features of American forests and the "personalities" of their most common trees. The author presents identifying features for over 150 different trees, and tells how their special characteristics are suited to the environment in which they live. He introduces many "friends" to the young reader; the hickories and butternuts in the Connecticut field, slash pines and cabbage palms in the Florida flatwoods, tall spruces in the Colorado mountains, and fragrant eucalyptus trees on the California hillside. Trees become "species and individuals rather than so many miles of wilderness to be pierced by a dual-line highway." *Animals in Armor* is a book about reptiles in the United States, including turtles, lizards, snakes, and crocodilians. Their lives, habits, and general features are discussed in a manner which should enable the young reader to overcome common misconceptions and fears of these animals which appear so different from familiar animals. *Animals in Fur* is an introduction to the mammals, their characteristics, habits, and habitats. The young naturalist meets here the burrowing gophers, climbing squirrels, powerful panthers, flying bats, and sea-going whales, as well as the lesser known armadillo and peccary. The central theme of the book is the adaptation of mammals to their particular environments. The author describes the various body structures and skills that enable the individual to solve his vital problems of food-getting and locomotion on the ground, in the trees, in the water, and in the air. *Insects on Parade* is a popular presentation of the science of entomology for the beginning naturalist. The author tempts the reader with a glimpse at the 700,000 different kinds of insects, their habits and appearance, what they eat, and how they get around. He describes many of the interesting facts of insect life, such as metamorphosis, migrations of hordes of locusts, and the social behavior of bees and ants. An introduction to the science of ornithology is given in *Feathers and Flight*. The young naturalist here learns about water birds, birds of prey, game birds, and other smaller land birds of the United States. The book describes the activities of birds at home, in the fields, and on the seashore, including their feeding, courting, and nesting behavior. Emphasis is again placed upon the many adaptations which have enabled each bird to live in its particular environment of rocky sea cliff, arctic tundra, or church steeple.

In these books the author has presented a multitude of scientific facts in a clear, enthusiastic fashion, supplemented with hundreds of illustrations. This series should help young readers enjoy the world around them, and will perhaps stimulate a scientific interest in many.

SHERWOOD M. REICHARD

BOY'S BOOK OF TURTLES AND LIZARDS.

By Percy A. Morris. The Ronald Press Company, New York. $4.50. vi + 229 pp.; ill. 1959.

In this book the author, Chief Preparator of the Peabody Museum of Natural History, Yale University, describes the turtles and lizards of the United States for the beginning naturalist. The distinctive characteristics, pecularities of habitat, and reproductive behavior are among the many

features of natural history of these reptiles presented by the author. The book is quite detailed but very readable, and should encourage an interest in turtles and lizards and perhaps in natural history in general for the beginner, young or adult. An expert photographer of nature, Percy A. Morris has illustrated the book profusely with excellent photographs of turtles and lizards in their natural surroundings, and these should be of value even to the more advanced herpetologist.

SHERWOOD M. REICHARD

WHITEFOOT MOUSE.

By Barbara & Russell F. Peterson; illustrated by Russell F. Peterson. Holiday House, New York. $2.50. 53 pp.; ill. 1959.

A truly happy combination of a husband-wife team of naturalists has prepared this vivid, very attractively illustrated account of the life and ways of the deer mouse *Peromyscus* for young children. Mrs. Peterson is the writer. Her husband is staff mammalogist at the American Museum of Natural History, the artist, and co-author. Without needless sentimentality but in warm sympathy for little living things, the authors describe the food-getting, efforts to escape predatory owls, shrews, and skunks, mating, nest-building, and ways with the young of the "whitefoot mouse." In every possible way the product is an outstanding child's book of natural history, immensely superior to most of what passes for such. Its scientific accuracy and its balanced ecological viewpoint are highly commendable. The Addendum of simple directions for keeping a mouse as a pet is a valuable inclusion.

BENTLEY GLASS

ECOLOGY AND NATURAL HISTORY

FUNDAMENTALS OF ECOLOGY. *Second Edition.*

By Eugene P. Odum; in collaboration with Howard T. Odum. W. B. Saunders Company, Philadelphia and London. $7.00. xviii + 546 pp.; ill. 1959.

This new edition is an even better ecology textbook than the first, which was published in 1953 (*Q.R.B.* 29: 151–2. 1954). The functional approach and critical elucidation of principles, which made its publication a notable event, are retained in the revised work. In this respect, it is written with a missionary zeal. Furthermore, it is probably the most up-to-date summary of knowledge in the rapidly expanding and crucial field of ecology.

Burgeoning human populations and increasing radioactivity provide the keynotes of emphasis in the new edition. Although the basic organization of the original work has been left unchanged, many sections have been extensively revised in the light of recent advances in ecology. Animal ecology is still the dominant theme, although plants receive careful treatment. An important review, Radiation Ecology, has been added. It is probably one of the best introductions available for both beginning ecologists and interested laymen. The energy and ecosystem chapters have been greatly augmented through the efforts of Howard Odum. Special attention has also been given to microbial ecology. As in the first edition, the book is divided into a discussion of principles, a statement of concepts with good examples, an introduction to freshwater, marine, and terrestrial ecology, and finally, the integration of these major sections of the book into a third section on applied ecology. The latter deals concisely with conservation, insecticides, fish and wildlife management, pollution, public health and welfare, radioecology (especially fallout and radioactive waste disposal), and the fate of human society.This potpourri makes surprisingly edible fare for even the most mildly interested person.

Future writers of textbooks in ecology, especially anyone tackling population ecology or any one of the several divisions of hydroecology, would do well to follow the Odums' "ecosystem" or "whole before the parts" approach. This simple approach invests in a student a sound background for research and better prepares him to evaluate critically the work of other people. The functional approach is carried even to the glossary, which one must dissect from the text by checking boldface page references in the index. The average, non-ecologically inclined student will wince at the requirement that he *understand* the terms and principles to which reference is made, rather than *memorize* mere definitions. It is to prevent the latter that there is no conventional glossary at the end of the book. The advantages of this teaching method are most obvious. Methods and specific techniques also take a back seat because, says the author, " . . . I feel strongly that the student should know why things are measured before he becomes too involved in the how." If part of Eugene Odum's enthusiasm is assimilated by students along with the how, what, and why of ecology, we can expect functional ecology to grow at far beyond its present rate.

Few ecology texts are as refreshing as this one, or as dedicated toward serving so many disciplines and specialists with such wisdom and comprehension. It is one of those amazing books that a beginning student or an experienced scientist can read with profit and interest. Indeed, the exigency

of our times suggests that the intelligent citizen would also do well to ponder part of its contents.

ROMEO MANSUETI

WE COME FROM THE SEA.

By Hans Hass; translated from the German by Alan Houghton Brodrick. Doubleday & Company, New York. $6.50. 288 pp.; ill. 1959.

Unlike many diving books—and there are bushels of them now—a book by Hans Hass is a report of legitimate scientific work as well as diving adventure. In this book he relates visits to the Azores whaling fishery, the Great Barrier Reef, the Galapagos, and various Caribbean scenes, as well as the usual shark episodes. There is a brief history of diving and a good short bibliography. The illustrations are for the most part excellent and some of them—of whales and sharks—are startling; but a few are too heavily retouched. One sequence, involving the shapely leg of a department store mannequin and the *Tridacna* whose shells "snap shut in a flash" is somewhat more theatrical than scientific; but on the whole the author and his crew stuck pretty well to the business of being scientists and photographing nature in the sea and on its shores. The translation is excellent; there are very few passages that read as if they had not been written directly in English.

J. W. HEDGPETH

WILDLIFE IN AMERICA.

By Peter Matthiessen; introduction by Richard H. Pough; drawings by Bob Hines. The Viking Press, New York. $10.00. 304 pp. + 8 pl.; text ill. 1959.

Never before has anyone attempted to record and document the full history of the far-reaching and often tragic effects on wildlife of the coming of the white man to the western hemisphere. To appreciate the vast changes that have occurred, one must first appreciate the natural state of the continent when the Indians were its sole occupants. This has been done by drawing upon an amazing number of natural history, narrative, and historical documents of the early days. Beginning with this latter-day Eden, with its vast herds of animals, teeming waters, and limitless clouds of birds above, the story is unfolded of man's limitless avarice and callow indifference which have resulted in steady decline to the conditions of decimation and extinction which make up the picture of North American wildlife today.

That the white man is the responsible agent is abundantly clear. The factor of human greed in the decline of bison, passenger pigeons, great auk, and beaver is already well known, but the author makes the point that, knowingly or otherwise, the white man has been responsible for changes that have affected almost every species of wildlife, either by direct or indirect means.

The subject matter is divided along ecological lines, as the chapter titles reveal. The Offshore Rocks, The Tropical Border, Fur Countries and Forest Lakes, and The High Air of a Continent are all titles that bespeak a separate and distinct assemblage of species which in different ways have reacted to the irresistible surge of white civilization across the land. The chapter, Another Heaven and Another Earth, deals prophetically with the chances of survival of such species as the condor, whooping crane, Bachman's warbler, and the Georgia blind salamander, which either teeter on the brink, or may already have crossed the invisible barrier between existence and extinction.

The book is real literature and will appeal to lay readers as well as professional biologists. It is magnificently illustrated with pen-and-ink drawings by Bob Hines, and there are also a number of plates selected from the works of naturalists and other early-day writers. The book is a true necessity for all administrators of conservation policy at both state and national levels. The lesson that it teaches is that nature can and will provide mankind with the wildlife that he craves, if he will but accommodate his activities to the habitat needs of the wildlife, and above all learn to curb his insatiable desire to kill and kill.

BRYAN P. GLASS

SOIL-PLANT RELATIONSHIPS.

By C. A. Black. John Wiley & Sons, New York; Chapman & Hall, London. $7.00. vii + 332 pp. + 1 folded chart; ill. 1957.

This book covers the subject matter of a course given by the author, who is a Professor of Soils at Iowa State College. While the major emphasis is on the physical, chemical, and biological properties of soils, the treatment is nevertheless slanted toward the soil as a substrate for plant growth. In 9 chapters the author brings together an immense amount of information useful to the plant scientist. As indicated by the following chapter headings, he begins with the basic questions of soil composition and continues through the various external factors which influence the soil as a substrate, to a final consideration of the three mineral macronutrients; nitrogen, phosphorus, and potassium. The chapter headings are: Soil Composition; Soil Water; Soil Aeration; Exchangeable Bases; Soil Acidity; Soil Salinity and Alkalinity; Nitrogen; Phosphorus; and Potassium. The author has done well in presenting the basic facts which underlie present understanding, but he also continually reminds the reader of

the many areas where the answers to vital questions await further research. The literature lists are well selected, and wherever possible the author refers the reader to the latest review articles on the subject concerned. The book should become a useful text for the advanced student of soils and a handy reference work for the plant scientist.

J. C. WALKER

EVOLUTION

SILICIFIED MIDDLE ORDOVICIAN TRILOBITES: *Remopleuridiidae, Trinucleidae, Raphiophoridae, Endymioniidae. Bull. Mus. comp. Zool., Vol. 121, No. 8.* *By H. B. Whittington. Museum of Comparative Zoology, Cambridge.* $3.75. (paper). ii + pp. 371–496 + 36 pl.; text ill. 1959.

Chemical separation of fossils from the embedding rock is effecting a revolution in invertebrate paleontology. Probably the most spectacular result of the new techniques was Kozlowski's study of the nature of graptolites, a group of paleozoic invertebrates which used to be related to the Hydrozoa and now turns out to be close to the Chordata. However, important discoveries are also being made in the trilobites, insects, brachiopods, and several still mysterious fossils such as conodonts and chitinozoans. The paleobotanists have not lagged behind in taking advantage of the new methods.

In certain cases—such as the graptolites and inarticulate brachiopods—the original chitinous or phosphatic composition of the skeleton renders it suitable for separation from the matrix by acids, even if no chemical changes have occurred in fossilization. In the trilobites the exoskeleton was calcareous like the surrounding limestone, and chemical separation is possible only where peculiar geochemical processes replaced the fossils, and only the fossils, with quartz or some other acid-soluble material. It is understandable that such occurrences are rare (for the trilobites so far limited to scattered localities, all in the United States).

In the latest monograph, his third on the subject, the author treats 4 trilobite families as represented at the famous silicified fossil localities in the Middle Ordovician of Virginia, which yielded the most perfect material of this kind found anywhere. The thoroughness of the descriptions and the perfection of the illustrations are fully up to the very high standard that we have come to expect from Whittington. Noteworthy is the great progress in the understanding of the ontogeny of the trilobite exoskeleton. Trilobite fossils in the earliest stages of development after hatching from the egg used to be scarce, poorly preserved, and difficult to interpret. Now one needs but to glance at some of the plates, many of them bearing stereoscopic reproductions, to realize that we would hardly know any better the skeletons of newborn trilobites if these animals were still alive in the oceans. Whittington's book will, like his previous ones, become a classic in the invertebrate paleontologist's library, and may well be of interest also to neozoologists.

F. RASETTI

LES FOUGÈRES SPHÉNOPTÉRIDIENNES DU BASSIN HOUILLER DU NORD DE LA FRANCE. *Contribution à l'Étude des Sphenopteris. Études Géologiques pour l'Atlas de Topographie Souterraine. I: Flore Fossile. 2nd Fasc. (2 vols.)*

By Jacques Danzé. Imprimerie Douriez-Bataille, Lille. (paper). 568 pp. + 4 folded tables + 86 pl. (separate volume); text ill. 1956.

Sphenopteris is one of those classical paleontological cognomens the meaning of which has varied so greatly with the advancing knowledge of fossil ferns and pteridosperms that it has lost all precision. According to the author of the present monograph, it may be taken to apply to certain ferns, eusporangiate or leptosporangiate, as well as to certain seed-ferns. Seven leptosporangiate fern genera, 8 eusporangiate genera, and 5 pteridosperm genera are here denominated the modern successors of the old sphenopteridian group. There are, of course, still many forms *incertae sedis* remaining to bear the name *Sphenopteris*. Those genera and species known from the classic locality of northern France are here described and discussed with all historical references, synonymy, and known characteristics. Volume 2 contains the collection of 86 magnificent plates to illustrate the descriptions and line drawings exhaustively presented in Volume 1.

THE VERTEBRATE STORY.

By Alfred S. Romer. The University of Chicago Press, Chicago. $7.00. viii + 437 pp.; ill. 1959.

Although this volume actually is a revision and enlargement of Romer's well-known *Man and the Vertebrates*, first published in 1933 and last revised in 1941, it emerges a virtually new book. The emphasis on man which characterized the original work has been discarded; indeed, the entire section on the human body, which constituted a third of the earlier volume, has been eliminated. On the other hand, the story of the vertebrates as a whole has been enlarged and a variety of new topics has been included. In consequence, over half of the text is new, thus justifying the new title.

Despite the undoubted excellence of *Man and the Vertebrates*, this new version is even a better and more useful work than its predecessor. It is, indeed,

a book that is near to being indispensable for any student of vertebrate biology.

W. L. Straus, Jr.

Natural Selection in Man. *Papers of the Wenner-Gren Supper Conference, held at the University of Michigan, April 12, 1957, during a meeting of the American Society of Human Genetics and the American Association of Physical Anthropologists. Arranged by J. N. Spuhler. Wayne State University Press, Detroit.* $3.50. vi + 72 pp. 1958. Although *Natural Selection in Man*, a collection of four papers, does not provide a comprehensive, integrated treatment of this broad subject, each paper is itself a worthy contrbiution to the study of the selective processes in human populations.

J. F. Crow's concise but substantial paper deals with the measurement of selection intensities in man at three levels: total, phenotypic, and genotypic. Since "selection can be genetically effective only if it is genotypic," it is that aspect which is considered in the most detail. The genetic load, "the extent to which [the population] is impaired by the fact that not all individuals are of optimum type," is divided into three components: (1) the mutational load, attributed to recurrent mutation; (2) the segregational load, attributed to mutants that decrease the fitness of homozygotes but are favorable in heterozygotes; and (3) the incompatibility load, attributed not to any genotype per se but rather to its reduced fitness with certain parents. Through mathematical models based on inbreeding in populations, it is concluded that the "mutation load rather than the segregational," is responsible for decreased fitness from inbreeding. Crow's suggested use of comparisons of parent-offspring and sib correlations in the measurement of the extent of mutational load in populations as well as his comments on the deleterious consequences of environmental change on the average population fitness also deserve some thought.

From a rather different but no less important approach comes Levine's empirical study of the interaction of ABO-incompatibility and Rh-incompatibility. Levine, who a few years after his keen explanation of erythroblastosis fetalis due to Rh-incompatibility suggested that ABO incompatibility protects against maternal Rh-isoimmunization, here presents statistical evidence to support that hypothesis. The only aspect with which one might take issue resides not in Levine's own work but rather in his apparent acceptance of the conclusions of Nevanlinna and Vainio (1956), who compared erythroblastotic fetuses in regard to ABO compatibility status without controlling on comparability of maternal titer or number of pregnancies following initial maternal isoimmunization.

C. C. Coon's presentation becomes much more than a merely delightful excursion based on the author's "anthropogeographic" tour around the world as he discusses evidence for the probable multiple origin of the population of North China, the physical variability of the Atayals, and the complexity of the racial history of Formosa, Beyer's hypothesis concerning the ancestors of the Philippine Negritos, India, a world in minature, and the "vast lip of the Himalayas, . . . the world's sharpest racial frontier." Just such keen observations as Coon reveals here "make" the scientist, and at the same time provide other investigators with both the raw material for theories and the necessary preliminary steps toward their empirical demonstration.

In J. V. Neel's discussion one finds a combination of the observer, the empiricist, and perhaps a touch of the theoretician. Neel answers "those who urge that selective pressures in human population are rapidly diminishing" as a consequence of decreased infant mortality and the preservation of persons with genetically determined diseases by indicating that "the genetic consequences of the apparent relaxation in . . . [certain] types of natural selection are not clear." He advocates a variety of studies on selective factors in advanced and primitive societies, "to understand man's past and predict his future."

Three different areas are suggested for the specific study of natural selection in human populations. The first area, the variability in individual reproductive performance in primitive and civilized cultures, leads the author to conclude that "striking differences in individual fertilities [are] not new," although "in terms of individuals reaching reproductive maturity [they] are probably more pronounced today than ever before."

While one might not challenge the genetic significance of changing dietary patterns, Neel's second suggested area for investigation, the genetic impact of the particular example, the relation of dietary fat to heart disease, might be questioned. For even if the diet-heart relationship were proven, its time of action must be clarified in terms of reduced fitness, since, according to Neel's own Michigan figures, 96.4% of heart disease mortality occurs after 44 years of age, when reproduction is usually completed. The third suggested area of study is that of genetic environmental interaction and balanced polymorphism, with the familiar but no less significant abnormal hemoglobins taken as example.

Certainly, whether or not one can accept all the views presented in the four stimulating papers comprising *Natural Selection in Man*, this compact little volume provides a refreshing variety of approaches to this anthropological genetic problem.

Bernice H. Cohen

GENETICS AND CYTOLOGY

BLAKESLEE: THE GENUS *Datura*. *Chron. bot., No. 20.*

By Amos G. Avery, Sophie Satina, and Jacob Rietsema; foreword and biographical sketch by Edmund W. Sinnott. The Ronald Press Company, New York. $8.75. xlii + 289 pp.; ill. 1959.

Most of our knowledge of the intimate details of plant cytogenetics and evolution has come from a deep and penetrating acquaintance with relatively few genera. In this sense *Datura* stands with *Oenothera, Crepis, Zea, Nicotiana,* and *Triticum* as a genus about which we know a great deal, and this knowledge will always be associated, in the annals of botanical science, with the name of A. F. Blakeslee and his co-workers. It was Blakeslee who initiated and guided the many-faceted studies of *Datura*: the work on the primary, secondary, and tertiary trisomics which demonstrated the genetic influence of large blocks of chromatin or whole chromosomes, a piece of work which nicely complemented the studies then being made on the effects of individual genes in *Drosophila* by Morgan and his school; the discovery of the first haploid among the vascular plants; the problems of segmental interchange, the resultant pairing relations at meiosis which helped to elucidate the *Oenothera* enigma, and the distribution of prime types as a means of approaching certain questions of evolution; the large problem of polyploidy, its effect on morphology and physiology, its induction with colchicine, its use in problems of developmental morphology, and its implications concerning genic balance; studies of the crossability of different races with the related aspects of pollen-tube growth, embryo abortion, atypical growth, and embryo culture; and the discovery of over 500 genes affecting varying characteristics of growth and behavior.

The volume is appropriately dedicated to Blakeslee by his associates who authored it. It is a fine, well-integrated summary of a monumental piece of work which spanned 40 years and which was originally reported in a series of over 400 papers. It is, of course, a fitting tribute to a great cytogeneticist, but it is equally a tribute to the three authors who were intimately associated with Blakeslee during these many years, and who have performed a service in bringing together in meaningful fashion an important segment of American biology.

C. P. SWANSON

GENETICS, RADIOBIOLOGY AND RADIOLOGY PROCEEDINGS, MID-WESTERN CONFERENCE.

Edited by Wendell G. Scott and Titus Evans. Charles C Thomas, Springfield, Ill. $5.50. xviii + 149 pp.; ill. 1959.

A conference held on May 2, 1958, and attended by 4 professors of genetics, 4 professors of radiobiology, and 21 professors of radiology was designed for the mutual education of geneticists and radiobiologists, to teach radiologists about genetic hazards, and for radiologists to demonstrate what is now being done to minimize radiation exposure of the gonads. Titus Evans and George A. Mickey discussed the mechanism of radiation damage. Irwin Herskowitz covered the factors affecting radiation-induced mutation rates. James F. Crow reviewed population aspects. W. L. Russell enumerated 18 points concerning mammalian radiation genetics. Arthur B. Smith and Hymer Friedell discussed the "accumulative dose concept" and "the dose response curve." The radiologists discussed practical aspects of radiation exposure in diagnostic and therapeutic radiology.

The published proceedings of the conference supply a useful review. Evidence of poor proofreading—*e.g.*, "positive effects" for "position effects" (p. 21), Mock and Lawrence for Macht and Lawrence (p. 87), 1937 for 1927 (p. 17)—somewhat mar the overall excellence.

VICTOR A. MCKUSICK

THE CELL. *Biochemistry, Physiology, Morphology. Volume I.*

Edited by Jean Brachet and Alfred E. Mirsky. Academic Press, New York and London. $22.00. xxiv + 816 pp.; ill. 1959.

This is a first of a 5-volume series on the cell. The series is conceived as a major treatise covering the physiology, biochemistry, and morphology of cells, and will consist of a collection of articles by recognized specialists in various areas of cytology. The first volume is divided into two portions, the first dealing with cytological methods, and the second with current problems in cytology. The contents of the method section are: Optical methods in cytology (R. W. G. Wyckoff); Fixation and staining (I. Gersh); Autoradiography (A. Ficq); Quantitative microscopical techniques for single cells (P. M. B. Walker and B. M. Richards); Quantitative microchemical techniques of histo- and cytochemistry (D. Glick); Microsurgical studies on living cells (M. J. Kopac); Isolation of subcellular components (V. Allfrey); and The cell as organism, 'tissue culture' cellular anatomy, and cellular interactions (P. R. White). Most of these articles are reviews of the areas specified rather than exhaustive and comprehensive treatments of the subject. Walker and Richards present the most current and detailed account in the first section.

The second section is devoted to problems of cell

biology. This section contains the articles: Fertilization, sex determination (L. Gallien); Differentiation in vertebrate cells (C. Grobstein); Patterns of cell growth and differentiation in plants (R. O. Erickson); Nucleocytoplasmic interaction in eggs and embryos (R. Briggs and T. J. King); The acquisition of biological specificity (J. D. Ebert); and Effects of radiation on cells (M. Errera). Each of these articles presents the background to the problem or problems under discussion, together with the state of the problems at the time of publication, and suggested avenues of investigation.

This series, when complete, should form an excellent reference work. It will be particularly useful to students as a broad introduction to research in cellular biology. If the first volume is any indication, it will not be a comprehensive reference work on cytological methods, cellular physiology, or ultrastructure. It would be difficult to envision such a treatise, however, because those fields are moving so rapidly that it has become virtually impossible to produce a comprehensive work which would not become quickly outdated.

R. R. COWDEN

SUBCELLULAR PARTICLES. *A Symposium held during the meeting of the Society of General Physiologists at the Marine Biological Laboratory, Woods Hole, Mass., June 9–11, 1958.*

Edited by Teru Hayashi. The Ronald Press Company, New York. $6.00. viii + 213 pp.; ill. 1959.

"We can all recall the categorical assertion that hope for significant information concerning the in vivo function of subcellular particles was lost the moment the cell was disrupted or homogenized.... Or, that electron microscopy was one huge blunder, based as it was on osmium artifacts." Thus A. B. Novikoff jests at the "gloomy critics," as he and a number of other workers on cell fractionation and electron microscopy review for other scientists some aspects of the area of biology-biochemistry-cytology they are expanding and integrating. These proceedings of a symposium of the Society of General Physiologists, held at Woods Hole, Massachusetts, in June 1958, show that the soap box from which Novikoff casts his jests is a sturdy one. True, the contents are not yet altogether pure.

An increasing value of correlated histochemical studies in conjunction with electron microscopy and biochemical analyses of cell fractions is most convincingly pointed out by Novikoff's results. One also begins to see in this article a growing cognizance of the real nature of the raw material so widely used in fractionation studies, *viz.*, organs and tissues, rather than homogeneous cell populations; and some questioning of the whereabouts and importance in the fractions of such structures as fragments of cell membrane, microvilli, etc.

G. E. Palade documents a trend in electron microscopy, away from the strictly morphological toward the physiological. He focuses his attention on the development of zymogen granules in the exocrine pancreas and a peculiar association of mitochondria and lipid inclusions in the cells of fasting animals. The mitochondria received a drastically different treatment from D. E. Green, an expert in the disruption of mitochondria into fragments, and the chemical and enzymatic characterization of these fragments. From his data Green constructs some reasoned guesses as to the states and functional relationships of the different portions of intact mitochondria. One begins to see here a potential for the dissection in vitro of a cytoplasmic organelle, paralleling the already partially fulfilled potential of cell fractionation.

The chemical composition and (mainly lack of) enzyme attributes of reasonably purified Golgi membranes are described by E. L. Kuff and A. J. Dalton. In his article Palade had speculated that these agranular membranes might serve as sacs, derived from the cytoplasmic membrane and used in carrying products of cell metabolism back to the cytoplasmic membrane for extrusion into extracellular spaces. Evidence for the existence of a separate class of large particles, lysosomes, is reviewed by C. de Duve. The lysosomes contain the bulk of cellular activities of acid phosphates, acid ribonuclease, acid deoxyribonuclease, cathepsin, beta-glucuronidase, and aryl-sulphatases A and B. Possibly still further subdivision of the larger cytoplasmic organelles into a new type with a discrete enzyme pattern is indicated by de Duve. In particular, uricase and catalase activities do not seem to correspond clearly with any of the heretofore named classes of granules.

Strangely out of vogue among biochemists are studies relating to the biochemical properties of the isolated nucleus. The interesting results of V. Allfrey and A. E. Mirsky, reviewed here, should provide further impetus in this field. M. L. Stephenson et al. describe the currently accepted sequence of soluble "intermediate" reactions leading to protein synthesis. J. H. Taylor and P. S. Woods review their autoradiographic findings which peculiarly indicate a semi-conservative partitioning of DNA in plant chromosomes, before they describe studies on the uptake of label into RNA of salivary glands of third instar *Drosophila* larvae. Structural and biochemical aspects of photosynthetic phosphorylation are discussed by M. D. Kamen and J. W. Newton. Two papers point out important general problems for future resolution on the basis of cell structure. The microheterogeneity of the cell and characteristics of enzyme reactions at interfaces are noted by

A. D. McLaren and K. L. Babcock. Structural factors in polymerization (leading to lignin and polyquinone formation) are discussed by S. M. Siegel.

PHILIP E. HARTMAN

GENERAL AND SYSTEMATIC BOTANY

ALGENKUNDE.

By Bohuslav Fott. Veb. Gustav Fischer Verlag, Jena. DM 48.90. viii + 482 pp.; ill. 1959.

The German edition of B. Fott's "algology" differs greatly from the original first edition which was published in 1956. The part of the book dealing with taxonomy has been completely rewritten, and the number of illustrations has been increased.

The author has succeeded in writing a textbook of algology which will prove to be of great value, both to the biology student and to the research worker in related fields. Indeed, Fott has harmoniously combined general information with special aspects. The content of the book has been divided into three main parts: the taxonomy; ecology; and technology of algae and their importance to man. By far the greater part is devoted to taxonomy. The author adheres to Pascher's system of taxonomy and applies taxonomical terms in accordance with the International Botanical Code of 1956.

The text is written in very clear German. The book has been extremely well illustrated with drawings and photomicrographs, including some electron micrographs. Although not primarily intended for the purpose, the book will, because of its generous illustrations, serve very well for identification of algological specimens. The student will appreciate the extensive chapters of general characterization preceding each larger taxonomic group. The research worker will find many references to pertinent literature at the end of each of the chapters.

Both the second and third parts of the book, treating the ecology of algae and their importance to man respectively, comprise about one-fifth of the volume. Not meant to replace standard works in these fields, both parts nevertheless supply ample information to the biologist and also outline many interesting problems for the technologist.

KONRAD KECK

PLANT PHYSIOLOGY

ANNUAL REVIEW OF PLANT PHYSIOLOGY. *Volume 10.*

Edited by Leonard Machlis; associate editor, John G. Torrey. Annual Reviews, Palo Alto. $7.00. viii + 483 pp.; ill. 1959.

Workers in the field of plant physiology owe a debt of gratitude to the editors of the *Annual Review of Plant Physiology*. The present volume marks ten years since the series was first started. During that time 158 reviews and two prefatory chapters have been published. These reviews were prepared by 207 different authors representing 15 different countries.

The contents of the present volume are as follows: Prefatory chapter (W. H. Chandler); Foliar absorption of mineral nutrients (S. H. Wittwer and F. G. Teubner); Leaf proteins (N. W. Pirie); Light induced reactions of bacterial chromatophores and their relation to photosynthesis (A. W. Frenkel); The structure of the chloroplast (J. J. Wolken); Active transport of salt into plant tissue (G. G. Laties); Respiratory mechanisms in higher plants (D. P. Hackett); Photoperiodic control of floral induction (J. Doorenbos and S. J. Wellensiek); The lignins (R. E. Kremers); Fat metabolism in higher plants (P. K. Stumpf and C. Bradbeer); The pine tree (N. T. Mirov and R. G. Stanley); Physiology of virus diseases (F. C. Bawden); Plant chemotherapy (A. E. Dimond and J. G. Horsfall); The macronutrient elements (T. C. Broyer and P. R. Stout); Nitrogen nutrition (R. H. Burris); Metabolism of carbon compounds (M. Gibbs); The chemical regulation of growth—some substances and extracts which induce growth and morphogenesis (F. C. Steward and E. M. Shantz); Auxins and fungi (H. E. Gruen); and Phototropism and phototaxis (J. Reinert).

The writing of review articles is a difficult and time-consuming task. Some authors only review the literature, while others attempt to review and interpret the published work of others. Both are represented in the present volume.

G. R. NOGGLE

INTRODUCTION TO PLANT PHYSIOLOGY.

By Bernard S. Meyer, Donald B. Anderson, and Richard H. Böhning. D. Van Nostrand Company, Princeton, Toronto, New York, and London. $7.50. vi + 541 pp.; ill. 1960.

This book is a short version of Meyer and Anderson's *Plant Physiology*, a textbook first published in 1939 and revised in 1952 (*Q.R.B.*, 28: 296, 1953). The change in title to *Introduction to Plant Physiology* and the addition of another author would suggest that some drastic changes had been made. However, this is not the situation. The style and organization of the earlier editions is closely followed, although sizable portions of the old text have been deleted. For the most part the deleted material includes discussions involving techniques of measurement.

Approximately one-third of the book is devoted

to problems of water relations, one-third to plant biochemistry, and one-third to growth and reproduction. Numerous advances have been made in all of these areas during the past ten years. In some instances the recent work has made it necessary to revise older concepts. One example will illustrate the point. The recent work on photosynthesis, leading to the concept of the chloroplast as the unit in photosynthesis, includes such topics as the fine structure of the chloroplast, photosynthetic phosphorylation, the use of tracers to elucidate the pathways of carbon, oxygen, and hydrogen, the comparative biochemistry of chloroplast enzyme systems, and the function of the different pigment systems. Most of the above topics are mentioned in this book, but they are "tacked on" to older concepts in a number of widely scattered places, so that the significance of the concept of the chloroplast as a unit of photosynthesis is lost. Other critical areas of modern plant physiology are treated similarly.

It was the authors' stated intention to develop a textbook that could be used in a one-semester or one-quarter course in plant physiology. The present book contains too much material for such a course, and the material is at too elementary a level. Plant physiology should be based on the concepts of chemistry and physics; concepts that require the techniques of measurement. These aspects of plant physiology have not been covered.

G. R. NOGGLE

PLANT PATHOLOGY. *An Advanced Treatise. Volume I. The Diseased Plant.*

Edited by J. G. Horsfall and A. E. Dimond. Academic Press, New York and London. $22.00. xiv + 674 pp.; ill. 1959.

This is the first volume of a projected three-volume assemblage of chapters on various aspects of plant pathology by specialists from several countries. The first volume contains articles on various aspects of disease development in the plant. The second volume is to be concerned with the pathogen. The third will emphasize epidemiology and control.

The first chapter of this volume is an introduction more to the eccentricities of the editors than to the subject of plant pathology. The professional pathologist is already accustomed to them while other biologists need not take them seriously. The editors choose to begin the "science" of plant pathology with the middle of DeBary's career (1866) and ignore the epochal scientific contribution of Prevost in 1807. For a reliable and well-documented history of the science the reader should go to Chapter 3. The second chapter is a survey of the "scope and contributions of plant pathology" and necessarily covers most aspects lightly. The author also ignores Prevost. The reviewer waded through the fourth chapter—How Sick is the Plant?—and classed it as a rather abortive attempt to impress the reader with the economic importance of plant diseases and how it can (and usually cannot) be estimated accurately. In the next chapter, as in many others, the title appears to be the result of editorial meddling rather than the choice of the authors. Tissue is Disintegrated is the title. It is a good résumé of the literature on fungus and bacterial exoenzymes as they affect living and dead host cells. Chapter 6 is also an excellent treatise on various types of abnormal growth in higher plants. The next three chapters are concerned with effects of disease on reproduction in the host, on host nutrition, and on water relations. Each leaves more than a little to be desired. Chapter 10 is a well-written discourse on the various ways in which respiration is altered in the plant during the course of disease development. Chapter 11, entitled Histology of Defense in Plants, is a survey of host reactions to fungi and bacteria as determined by histological and cytological techniques. Its incompleteness is shown in the fact that it ignores completely the classical papers of Ruth Allen on *Puccinia graminis* in relation to wheat tissue. Chapter 12 contains a thorough review and evaluation of papers on the physiology and biochemistry of host reactions to pathogens. This is followed by chapters on hypersensitivity, predisposition, and therapy. The last chapter, like the first, is so poorly written that it does not deserve further mention.

J. C. WALKER

ECONOMIC BOTANY

DIE ENTSTEHUNG DER KULTURPFLANZEN. *Verständliche Wissenschaft, Band 63.*

By Franz Schwanitz. Springer-Verlag, Berlin. DM 7.80. 151 pp.; ill. 1957.

This little volume was written to commemorate the 75th birthday of Elisabeth Schiemann, a distinguished student of the origins of cultivated plants. The book is worthy of its purpose.

The first chapter, one of four, describes the numerous kinds of differences which occur between cultivated plants and their wild ancestors. The cultigens are often more luxuriant in growth; they tend to have larger leaf areas and to be more efficient in capturing solar energy. They may be more tender and succulent because their larger cells hold more water. Mechanisms for dispersal are lost or partially suppressed; bitter or toxic substances are eliminated or reduced in amount. Spines and thorns, needed by the wild plant for survival in nature, are reduced or lost. Seeds of cultigens

tend to ripen simultaneously and to germinate more quickly and uniformly than those of their wild counterparts. The cultigens may be earlier maturing, thus insuring successful crops in short seasons or, if they are grown for vegetative parts such as leaves or roots, rather than for seeds, they may become biennials, thus making it possible for the first year's growth to be devoted to the production of those plant parts which are most useful to man.

The second chapter, concerned with the hereditary basis of the evolution of cultivated plants, discusses the well-recognized phenomena of gene mutation, selection, hybridization, and polyploidy. Of particular interest is the description of the modern breeding of lupines as a model of evolution under domestication. Applying known principles of genetics, breeders have, in thirty years, converted lupines from wild plants to cultigens with larger seeds, lower alkaloid content, and nonshattering pods. Enormous numbers were handled; one nonshattering mutant was found in some 10 million plants studied. It is postulated that changes such as these have occurred in the older cultigens but that their evolution was much slower.

The third chapter treats the influence of the environment and deals especially with secondary domestication. Numerous examples are cited of plants becoming cultigens by first entering agricultural systems as weeds. As the primary cultigens have evolved, the weeds have evolved with them and in some instances have become secondary cultigens.

The last chapter discusses plant breeding as a form of man-influenced evolution, and both ancient and modern examples are cited. The dates given in this chapter for the origins of several cultigens do not take full cognizance of recent archeological data bearing on this subject.

The book is profusely illustrated with photographs, drawings, and diagrams, and the majority of illustrations are excellent and effective. The bibliography is limited and is largely confined to a few standard works.

PAUL C. MANGELSDORF

PLANT PROPAGATION. *Principles and Practices.* *By Hudson T. Hartmann and Dale E. Kester. Prentice-Hall, Englewood Cliffs.* $8.75. x + 559 pp.; ill. 1959.

This is a comprehensive book dealing with both the theoretical and practical aspects of plant propagation. It covers all aspects of seed production and propagation, asexual propagation by cuttings and layers, and propagation by grafting and budding. It also includes a description of structures, equipment, and materials used in propagation. The book is illustrated with more than 200 figures and photographs, showing essential aspects of techniques and the results of experimental procedures.

The outstanding feature of the book is its treatment of theoretical aspects with the practical applications. The literature references are remarkable in their thorough coverage of the broad aspects of plant propagation. These include not only recent publications in the field of plant physiology, but also much of the older work, including that of Daniel, Sachs, and Knight. In addition to the literature citations, there is a list of publications for supplementary reading at the end of each chapter.

In addition to covering the general aspects of plant propagation, specific information is included for the propagation of most of the fruit and nut tree species grown in this country and all of the major ornamental trees and shrubs. Because of its encyclopedic coverage this book should be of value as a reference book for horticulturists, both amateur and professional. As a textbook it is outstanding because it presents clearly and concisely the essential basic information as well as the practical application.

KARL SAX

THE GARDEN FLOWERS OF CHINA. *Chron. Bot., No. 19.* *By H. L. Li. The Ronald Press Company, New York.* $6.50. vi + 240 pp. + 18 pl.; text ill. 1959.

China rightly deserves the title of "The Mother of Gardens." Its contributions are such as would impoverish, in a most serious and significant way, most of the gardens of the world if they were to suddenly disappear from the horticultural scene. Only the gardens of the tropics would remain relatively unchanged by such a removal.

The list of China's contributions to our own gardens and landscape is an impressive one. Perennials and shrubs predominate. The better-known include the peony, chrysanthemum, camellia, forsythia, wisteria, magnolia, roses of various kinds, day lilies, azaleas, rhododendrons, and the flowering crabs, cherries, plums, peaches, and apricots. The reasons, of course, are not difficult to find. Geographically, China is a vast area of varied climates and habitats; geologically, it was largely unglaciated at the time when Europe and North America were being floristically depopulated. No less important is the fact that the Chinese culture, with its love of flowers, so preserved, protected, and brought to perfection those plants of conspicuous beauty that they have become an integral part of the Chinese way of life. Their silks, porcelains, homes, and gardens reflect this in a way unmatched by any other civilization.

In handling his subject, H. L. Li has dealt with much of the lore and legend associated with the flowers of China while at the same time providing sound information as to origin, species, time of introduction outside of China, and use. Chinese names and symbols for various plants are also translated. This is not a definitive nor, indeed, a scholarly volume; the subject is far too large and the whole topic too intricate for so short a book. It is, however, a charming, delightful, and informative volume, and this was what it was intended to be.

C. P. SWANSON

FOREST FIRE. *Control and Use. The American Forestry Series.*

By Kenneth P. Davis, George M. Byram, and W. R. Krumm. McGraw-Hill Book Company, New York, Toronto, and London. $12.00. xiv + 584 pp.; ill. 1959.

All persons with a serious interest in forest fire control will find this book a valuable reference work, since it integrates much information from many widely scattered and not readily available sources. The information on combustion, fire behavior, and fire weather is especially valuable, since manuals and handbooks on forest fire control usually give these topics scanty coverage. The book also appears to be well adapted for use as a textbook in forestry school fire control courses, but the price ($12.00) will most likely discourage a very extensive sale.

The treatment of fire effects and behavior is excellent and could hardly be shortened. But the section dealing with forest fire control methods and techniques appears to be unnecessarily lengthy and has undoubtedly contributed much to the cost of the book. The discussion of fire control objectives is adequate but it bypasses the important basic questions of who should provide forest fire control services and who should pay the costs. The use of fire as a tool in forest land management is rather briefly treated, but sufficient examples are included to illustrate the techniques involved.

SCOTT S. PAULEY
FRANK D. IRVING

GENERAL AND SYSTEMATIC ZOOLOGY

THE INVERTEBRATES: *Smaller Coelomate Groups: Chaetognatha, Hemichordata, Pogonophora, Phoronida, Ectoprocta, Brachiopoda, Sipunculida. The coelomate Bilateria. Volume V.*

By Libbie Henrietta Hyman. McGraw-Hill Book Company, New York, London, and Toronto. $14.50. viii + 783 pp.; ill. 1959.

The present volume of this series includes all the smaller coelomate groups not in Volume IV, other than the Echiurida, which will come later. Miss Hyman states that she hopes to complete the next two volumes, covering the Annelida and Mollusca, but, because of circumstances of age and health, she cannot contemplate dealing with the Arthropoda. The overall task, however, has been so immense that it would have been a miracle if any one person could have accomplished it in a lifetime, and even then the earlier work would be outdated. We are very fortunate that Miss Hyman has succeeded in doing so much and so extremely well. These first five volumes are a triumph by themselves, and if the annelids and molluscs also are given to us in the near future, as the author hopes, altogether the treatise will be monumental indeed.

As for the present volume, it is fully up to the standard set by its predecessors. The Ectoprocta are considered as a phylum distinct from the Endoprocta and are placed among the lophophorate coelomates, between the Phoronida and the Brachiopoda. The divorce is probably justified, but the degree of separation into different volumes seems somewhat extreme. The chaetognathe problem is fully discussed, and the conclusion reached that they are in no way related to the aschelminths but should be regarded as having diverged at an early stage from the primitive ancestor of the Bilateria at the time the dipleurula ancestor became differentiated. Hemichordates are considered to have arisen from a common stock with the echinoderms but are fully and definitely invertebrates, with only a tenuous connection, via gill slit morphology, with the chordates. The Pogonophora follow the Hemichordata as a distinct phylum with affinities with the latter. Finally the Sipunculida, also raised to a full phylum, are recognized as having a strong annelidan relationship and lead the way to the next volume to come.

Generally speaking, however, the various groups treated as independent phyla here are described and discussed in full and suggestive detail. The possible interrelationships are intriguing, and the author's conclusions are always interesting and often challenging. Altogether we have a fascinating puzzle, with probably nearly all the pieces in front of us, and this book is primarily food for thought. The last chapter is perhaps an insurance against a callous future, for it is called Retrospect, and it reviews the many advances made concerning the subject matter of the first four volumes. It is also refreshing to read, for Miss Hyman is at her caustic best when writing of theories and concepts with which she disagrees. A protozoan has no more

chance of entering the kingdom of cells than the camel through the needle's eye. Long reign her majesty.

N. J. BERRILL

THE EARTHWORM FAUNA OF NEW ZEALAND. *Bull. 130.*

By K. E. Lee. New Zealand Department of Scientific and Industrial Research, Wellington. £3. 486 pp.; ill. 1959.

The major portion of this book, perhaps 380 out of 480 pages, is devoted to a businesslike description of the earthworm fauna of New Zealand. The final 100 pages is a discussion of the geographical distribution of the native species and their relationship to soil types.

In the orthodox manner of taxonomic monographs, the name of each of the 178 indigenous and 14 introduced species is followed by a list of specific references, a technical diagnosis, and a brief description of salient traits, range, and habitat. The frequent line drawings (there are over 350) are commendable. So also is the inclusion of discussions of genera, a duty sometimes overlooked by taxonomists. Identification keys are provided at the generic and specific levels, in addition to tabular comparisons of series of species, trait by trait. Four new genera and 53 new species of megascolicids are described.

The author is quite properly dissatisfied with the present state of earthworm classification, but has attempted only the most modest efforts at improvement over the equally modest attempts begun by Gates and Pickford.

The general reader will be interested to note that, although there are well over ten times as many indigenous as introduced species, the foreign species, mostly from Europe, have almost completely replaced the native ones wherever the soil is cultivated.

GAIRDNER MOMENT

MARINE MOLLUSCA OF POINT BARROW, ALASKA. *Proc. U. S. nat. Mus., Vol. 109, No. 3412.*

By Nettie MacGinitie. Smithsonian Institution, Washington. Free upon request (paper). Pp. 59–208 + 27 pl. 1959.

Point Barrow is the most northerly point of Alaska, and except for the Boothia Peninsula it is the most northerly point of the American mainland. Its molluscan fauna appears to be rather scanty. Its most surprising feature, however, is not its small size but the fact that it is essentially an Atlantic fauna. Many of its species occur on the Atlantic coast as far south as Cape Cod, while few have succeeded in penetrating Bering Strait.

A glance at the map seems to indicate that the temperature of the water may be the controlling factor. Mollusca are known to be sensitive to changes of temperature. Bering Strait is very narrow and shallow and the volume of cold water which makes its way through it into the Bering Sea to the south must be negligible when compared to the much larger quantity of temperate water brought in by the Japanese current. On the other side of the continent Baffin Bay is several hundred miles in width, and its depth must be proportional, so that the cold Labrador current meets no obstacle to its progress between the Arctic Ocean and Newfoundland.

A geological factor also may be involved. It is generally believed that in the Pleistocene a land bridge connected Cape Dezhneva with Cape Prince of Wales, making impossible any biological intercourse between the Pacific and the Arctic, but there is no evidence that North America and Greenland were ever connected.

The author has done a very thorough piece of investigation. She has gone over a great deal of literature not readily available in research libraries and has submitted her material to authorities in both this country and Europe for diagnosis. There is general agreement among them as to what forms she had, but there is some divergence of opinion as to the names by which they should be called. It would be expecting too much to ask for a code of rules governing nomenclatorial procedure that would anticipate every contingency, and there will also be differences of opinion concerning the legal availability of some names. But when a writer finds that a rigid application of the rules makes it necessary to reject a familiar name in favor of one that is less well-known, the change-over could be made more easily if the reasons for it were given. Lack of statement of such reasons is perhaps the weakest feature of this publication.

As this work is pressed more carefully, one is struck by the great variability of the species of this species of fauna. The nomenclature adopted by Middendorff to provide names for all recognizable varieties testifies to this variability, and the thought naturally follows: is it possible that the effect of cold water is to retard the elimination of the unfit, so that the intergrading "missing links" are preserved along with the types that they connect, and that when the population succeeds in establishing itself in a warmer environment these fail to survive, and hence a population consisting originally of a higher variable species becomes converted into a number of less variable species through the loss of the intergrading forms? Many years ago Chaster

maintained that two forms specifically distinct in one locality might constitute only a species and a variety in another.

The work is amply illustrated. Of the 158 species and varieties reported no less than 134 are figured, some more than once. The subgenus *Lampeia* and the species *Neptunea middendorffiana* and *Thracia adamsi* are described as new.

JOSHUA L. BAILY, JR.

CRUSTACEA: PENAEIDA. *Part II. Series Benthesicymae. The John Murray Expedition 1933–34. Scientific Reports. Brit. Mus. (nat. Hist.), Vol. X, No. 7.*

By Nasima M. Tirmizi. British Museum (Natural History), London. £1 5s. (paper). Pp. 321–383; ill. 1960.

THE SPIDER GENERA *Achaearanea, Theridion and Sphyrotinus* FROM MEXICO, CENTRAL AMERICA AND THE WEST INDIES (ARANEAE, THERIDIIDAE). *Bull. Mus. comp. Zool. Harv., Vol. 121, No. 3.*

By Herbert W. Levi. Museum of Comparative Zoology, Cambridge. $2.50 (paper). ii + pp. 57–163; ill. 1959.

This work is primarily taxonomic, and consists of descriptions, for the most part quite meager, of 174 species, of which 98 are considered as new to science. The author admits that the separation of the three genera is difficult, and that the placement of some species may be arbitrary, especially with regard to the females, which do not possess good diagnostic characters.

The author displays inconsistency in bibliographic citations. In repeatedly refering to his papers of 1955, 1956, and 1957, he gives in some places the reference to the third paper in full, but in other places the name of the journal is lacking. Nowhere in the current contribution does he supply the name of the journal for his 1955 paper. This was perhaps an accidental oversight, but will be quite disconcerting to most readers, especially to the newer workers in the field.

Another type of inconsistency concerns the quality of the descriptions, which is very uneven. In a few cases, as when describing *Theridion davisorum*, he points out how the species differs from another, *T. cameronense*, "in that the openings of the epigynum are further from the margin." But in most places the author says only that "the genitalia distinguish this species," or perhaps that the "abdomen is modified." Just exactly *what* the differences or the modifications may be cannot be ascertained from his descriptions. There are no analytical keys, and it is obvious that to identify specimens recourse must be had to the illustrations, which are mostly of genitalia.

B. J. KASTON

A REVISION OF THE PLATYSEIINAE (MESOSTIGMATA: ACEOSEJIDAE) *Based on Material in the Collections of the British Museum (Natural History). Bull. Brit. Mus. (nat. Hist.) Zool., Vol. 6, No. 2.*

By G. Owen Evans and K. H. Hyatt. The British Museum (Natural History), London. 24s. (paper). ii + pp. 27–101; ill. 1960.

THE SYSTEMATICS OF *Tetragoneuria*, BASED ON ECOLOGICAL, LIFE HISTORY, AND MORPHOLOGICAL EVIDENCE (ODONATA: CORDULIIDAE). *Misc. Publ. Mus. Zool. Univ. Mich., No. 107.*

By Edward J. Kormondy. University of Michigan, Ann Arbor. $1.20 (paper). 79 pp. + 4 pl.; text ill. 1959.

THE ACROMETOPA OF THE ETHIOPIAN REGION: A REVISION, WITH NOTES ON THE SEXUAL DIMORPHISM SHOWN BY THE GROUP (ORTHOPTERA: TETTIGONIIDAE). *Brit. Mus. (nat. Hist.) Entomol., Vol. 8, No. 7.*

By D. R. Ragge. The British Museum (Natural History), London. 20s. (paper). ii + pp. 270–333; ill. 1960.

THE EARLY LITERATURE ON MALLOPHAGA (PART IV, *1787–1818.*) *Bull. Brit. Mus. (nat. Hist.) Entomol., Vol. 9, No. 1.*

By Theresa Clay and G. H. E. Hopkins. The British Museum (Natural History), London. 27s. 6d. (paper). 61 pp. + 5 pl.; text ill. 1960.

A REVISION OF *Glaucina, Synglochis,* AND *Eubarnesia* (LEPIDOPTERA, GEOMETRIDAE). *Bull. Amer. Mus. nat. Hist., Vol. 118, Art. 6.*

By Frederick H. Rindge. American Museum of Natural History, New York. $2.00 (paper). iv pp. 263–365 + pl. 23–27; text ill. 1959.

This systematic revision covers a small group of geometrid moths found primarily in the arid regions of the southwestern United States and northern Mexico. Its general interest lies in the fact that it furnishes us a sad commentary on the exceedingly incomplete state of our systematic knowledge of the thousands of North American moths that have not yet received modern systematic study. Of 4 genera, 1 is new; of 38 species, 15 are new; of 8 non-nominate subspecies, 5 are new; and there are 14 new nomenclatorial combinations. Very definitely the moths, even the "macros," are a wide open field, lacking only competent workers. In this monograph the following are included for each species and subspecies: a complete distribution map, and seasonal and locality data; descriptions and figures of both male and female genitalia, and adult patterns and colors; complete bibliography; all known information about the early stages and food plants; photographic illustrations from 1 to 4 adult specimens, types when possible; discussions and data of all type material known, with designations of lectotypes when possible. There are also figures of the

head outlines of many species; complete keys to all genera and species; statements of the type species of the genera; and general discussions and descriptions of methods and materials, phylogeny, and taxonomy. All available specimens (including types) in all museums were studied. There are relatively few workers in any field of systematic research who could not benefit from emulation of the clarity, accuracy, and completeness of such work.

ALEXANDER B. KLOTS

NEW SPECIES OF INDO-AUSTRALIAN GEOMETRIDAE. *Brit. Mus. (nat. Hist.) Entomol., Vol. 6, No. 12.*

By L. B. Prout. British Museum (Natural History), London. 28s. (paper). ii + pp. 367–463; ill. 1958.

The monumental Seitz' *Macrolepidoptera of the World* has been in the process of being published, in irregular batches of color plates and text, with some supplements, ever since 1906. The late L. B. Prout of the Department of Entomology, British Museum (Natural History), had prepared much of Volume 12, on the Indo-Australian Geometridae, when World War II cut off his communication with the publishers in Stuttgart. In 1940–41 Plates 29–34, 36–41, and 50 were published with a trivial name accompanying each illustration of a specimen, but the manuscript of the text was lost during the bombing of Germany. This meant that many new Prout trivial names existed in a sort of nomenclatorial semi-vacuum. The situation was further complicated by the misspelling or erroneous transposition of many of the names. Prout died in 1943 without having been able to do anything about it.

Part I of the present publication was prepared from Prout's notes and papers by D. S. Fletcher of the British Museum and covers the taxa that were to have been completely published in Vol. 12 of Seitz. It includes 1 genus, 99 species, 55 subspecies, 10 aberrations and forms, and 2 nomina nova. For each there is given a short description and distinction, the data of the type series, the location of the type or types, and the reference to the published figure.

Part II consists of the original descriptions of many other Indo-Australian Geometridae which had been prepared by Prout but which have been hitherto unpublished. These total 1 new genus, 58 new species, 45 new subspecies, 5 new aberrations and forms, 1 nomen novum, and 1 more adequate description of a previously published species. Data are given as above; and a series of 72 photographs illustrates the holotype, allotype, or a paratype of the majority of the new taxa.

The work will do much to clear up a very tangled nomenclatorial and taxonomic situation for students of nomenclature and of the systematics of these moths, but it is of little general interest except as an illustration of the complexities of nomenclature.

ALEXANDER B. KLOTS

SYNOPSIS OF THE SPECIES OF AGROMYZID LEAF MINERS DESCRIBED FROM NORTH AMERICA (DIPTERA). *Proc. U. S. nat. Mus., Vol. 108.*

By Kenneth E. Frick. Smithsonian Institution, United States National Museum, Washington. Free upon request (paper). Pp. 347–465; ill. 1959.

This is a greatly needed publication, since no comprehensive study of the North American Agromyzidae has been made since the time of A. L. Melander and J. R. Mallock in 1913. Many new species have been described and considerable changes in synonymy have occurred since those early papers.

This paper deals with the Agromyzidae, especially the species originally relegated to the genera *Agromyza* and *Phytomyza*. Frick has wisely followed the classification of the European workers, including 15 genera and 206 species. Keys to the genera and species are provided, including the Neo-tropical as well as Nearctic species. Valuable additions are a list of the host plants of the North American species and 170 figures ilustrating head, thorax, and wing characteristics. A limited list of outstanding papers dealing with the original descriptions and redescriptions of species is included. It is regrettable that some of the outstanding papers describing new North American species have been omitted.

S. W. FROST

CONTRIBUTIONS TOWARD A RECLASSIFICATION OF THE FORMICIDAE. III. TRIBE AMBLYOPONINI (HYMENOPTERA). *Bull. Mus. comp. Zool. Harv., Vol. 122, No. 4.*

By William L. Brown, Jr. Museum of Comparative Zoology, Cambridge. $1.25 (paper). ii + pp. 145–230; ill. 1960.

A PRELIMINARY REVIEW OF THE FAMILY GONOSTOMATIDAE, WITH A KEY TO THE GENERA AND THE DESCRIPTION OF A NEW SPECIES FROM THE TROPICAL PACIFIC. *Bull. Mus. comp. Zool. Harv., Vol. 122, No. 2.*

By Marion Grey. Museum of Comparative Zoology, Cambridge. $1.25 (paper). ii + pp. 58–125. 1960.

A SYSTEMATIC STUDY OF THE LIZARDS OF THE DEPPEI GROUP (GENUS *Cnemidophorus*) IN MEXICO AND GUATEMALA. *Misc. Publ. Zool. Univ. Mich., No. 111.*

By William E. Duellman and John Wellman. Museum of Zoology, University of Michigan, Ann

Arbor. $1.75 (paper). 80 pp. + 1 pl.; text ill. 1960.

ECONOMIC ZOOLOGY

PIG CARCASS EVALUATION. *Technical Communication No. 12 of the Commonwealth Bureau of Animal Breeding and Genetics, Edinburgh.*

By G. Harrington. Commonwealth Agricultural Bureaux, Farnham Royal, Bucks, England. 15s. xii + 107 pp.; ill. 1958.

This is the first of a series of reviews dealing with research in the appraisal of pig carcass quality. The author has culled information from several situations varying from scientific experiments to slaughterhouse grading. Techniques used in many countries are described. With an outline of the following problems the book is intended to indicate three important areas for future research: the determination of fat content in live pigs and intact carcasses; the role of carcass measurements and visual assessments in judging traits which are commercially desirable; and evaluation of consumer preferences.

Although during recent years there has been an increasing demand among agriculturists and others for precise measurement of important qualities in pig carcasses, research in this area has been lagging. This book indicates clearly what methods are available, and gives direction for future experimentation. The material is concise and well presented.

HAROLD H. VARON

ECHO SOUNDING EXPERIMENTS IN THE BARENTS SEA. *Fish. Invest., Lond., Series II, Vol. XXII, No. 9.*

By I. D. Richardson, D. H. Cushing, F. R. Harden Jones and two other contributors. Her Majesty's Stationery Office, London. £1 0s. 0d. (paper). vi + 57 pp.; ill. 1959.

ANIMAL MORPHOLOGY

THE EXTREMITIES. *Second Edition.*

By Daniel P. Quiring; edited by John H. Warfel. Lea & Febiger, Philadelphia. $3.25. 120 pp.; ill. 1960.

This book is designed as an aid in the study of the muscles of the extremities, highlighting their principal anatomical features. It is organized as a series of outline figures, one for each of the muscles of the girdles and extremities. The figures illustrate the significant skeletal relations, motor point(s), and nerve and arterial supply. Origin, insertion, and function are described briefly, and appropriate page references are made to the 27th edition of Gray and the 9th edition of Cunningham. More information on variations would be valuable, the statement, "This muscle is inconstant; absent in 40 per cent of bodies," referring to psoas minor, being the only one given. If used as intended, that is, as an *aid* in study and review, the value of the book is clear. There is, however, an unfortunate tendency for the student to ignore the specimen and text in favor of thumbnail descriptions and synopses, whereby he realizes a less than desirable understanding of regional organization.

Changes in the second edition include some rearrangement in the order of presentation of the muscles, correction of anatomical errors, and revision of terminology to conform to the 1955 (Paris) Nomina Anatomica.

WILLIAM J. YOUNG

THE COMPARATIVE MORPHOLOGY OF THE CAROTID BODY AND CAROTID SINUS.

By William Edgar Adams. Charles C Thomas, Springfield, Ill. $10.50. xviii + 272 pp. + 5 pl.; text ill. 1958.

This monograph is just what its title implies—a description of the structures of the carotid fork throughout the vertebrate series. The book is composed of 3 sections: an excellent and detailed account of the development of knowledge regarding the carotid body and sinus, a description of these structures in mammalia; and an account of them in birds, reptiles, amphibia, and fish.

Although much of his material is derived from previously published work of other anatomists, the author, on the basis of many years of experience in the field, has critically selected, carefully analysed, and skilfully interpreted the world literature. His text, therefore, gives an authoritative, accurate, and well-illustrated treatise on the subject.

In spite of the difficulties of obtaining bibliographic sources in his native land, Adams has produced a remarkably complete and accurate bibliography of the subject.

The reader must regret, however, that the author did not see fit to incorporate in his discussion an account of the physiology of the carotid sinus and body. Although, as he states, several books have been written on this aspect, a review in the author's own concise and clear style would have been welcome.

This well-written and scholarly book will be a useful reference volume for a large group of biologists and physicians who have occasion to deal with the carotid body and sinus in the course of their work.

A. EARL WALKER

RETICULAR FORMATION OF THE BRAIN. *Symposium sponsored by the Henry Ford Hospital, Detroit, Michigan, and held at the hospital March 14, 15, 16, 1957.*

Edited by Herbert H. Jasper, Lorne D. Proctor, Robert S. Knighton, and Russell T. Costello. Little, Brown & Company, Boston and Toronto. $16.00. xvi + 766 pp.; ill. 1958.

The 38 papers in this Symposium cover all aspects of the anatomy and neurophysiology of the reticular formation. The role of the reticular formation in clinical neurology is also considered to a limited extent. All of the papers are interesting, and most of them contain new work that is not available elsewhere. The discussions that accompanied the original presentations of the papers are also reproduced. Both the papers and discussions have their subject matter well indexed. The book will certainly become an indispensable part of the reference library of every serious student of the mammalian central nervous system.

MYRON L. WOLBARSHT

THE BIOLOGY OF MYELIN. *Progress in Neurobiology: Volume IV.*

Edited by Saul R. Korey. A Hoeber-Harper Book, New York. $9.50. xxiv + 405 pp.; ill. 1959.

Contents: Ultrastructure of nerve myelin and its bearing on fundamental concepts of the structure and function of nerve fibers (F. O. Schmitt); Biology of myelin: Other membrane-limited structures of cells (K. R. Porter); The fine structure of the morphogenesis of myelin (S. A. Luse); Genetics and myelinization (P. J. Harman); Abnormalities of the nervous system in the mouse (S. Gluecksohn-Waelsch); Chemistry of myelin development (J. Folch, J. Casals, A. Pope, J. A. Meath, F. N. LeBaron and M. Lees); Lipid biosynthesis by peripheral and central nervous tissues as a function of age (M. L. Karnovsky, H. Moser and G. Majno); Physiologic properties of the myelin sheath and of the node of Ranvier (I. Tasaki); Some aspects of myelin in nerve trunks (A. M. Shanes); Myelin formation in cultures of mammalian central nervous tissue (W. Hild); Factors bearing on myelin formation in vitro (M. R. Murray); Observation on glial metabolism: Water and electrolyte distribution (K. A. C. Elliot); Metabolism of the Schwann cell (R. J. Rossiter and J. F. Berry); A radioisotope study of nucleic acid and protein turnover in white matter of the mammalian neural axis (H. Koenig); The enzymic synthesis of phospholipids (E. P. Kennedy); Myelinization and the synthesis of fatty acids and cholesterol (H. Waelsch); Plasmalogen structure and the chemical reactivity of α,β-unsaturated ethers (M. M. Rapport); Wallerian degeneration and regeneration of peripheral nerves (R. D. Terry and J. C. Harkin); Experimental allergic encephalomyelitis: Its production, prevention, and pathology as studied by light and electron microscopy (R. M. Condie and R. A. Good).

The date when this symposium was held seems to have been deliberately omitted. Since the latest references are dated 1958 and there are but few of these, the publisher must be embarrassed at the delay. Many of the articles are related to myelin in only a satellite fashion, even those that by title seem to fit the theme. Porter, for example, discusses essentially all membranes except those of sheath cells. Consequently, the contents should appeal to a wider audience than the title suggests. The ensuing discussions by the 51 participants have been included. A subject index and a table of contents to previous volumes in the series are provided. The latter does not give either the symposium dates or publication dates.

DAVID R. EVANS

A MANUAL FOR HISTOLOGIC TECHNICIANS.

By Ann Preece. Little, Brown & Company, Boston and Toronto. $6.00. x + 219 pp.; ill. 1959.

This book has been prepared chiefly for the training of medical technicians who will be required to handle tissues in a pathology laboratory. For this reason, the schedules and preparation methods which are given strongly reflect the established routines of the author's own laboratory. The manual contains excellent practical directions to the beginner for preparing sections and correcting faults in tissue preparation. The list of techniques given encompasses almost all of the methods a technician in a histopathological laboratory would encounter. While it is undoubtedly an excellent guide for histopathological technicians in training, because of its limited scope it cannot be enthusiastically recommended as a training manual for students in zoology or anatomy.

R. R. COWDEN

ANIMAL PHYSIOLOGY

HANDBOOK OF PHYSIOLOGY. *A Critical, Comprehensive Presentation of Physiological Knowledge and Concepts. Section 1: Neurophysiology. Volume 1.*

Edited by John Field, H. W. Magoun, and Victor E. Hall. American Physiological Society, Washington; Williams & Wilkins, Baltimore. $22.00. xiv + 779 pp.; ill. 1959.

The American Physiological Society plans to publish a series of books under the present title that will, at first, cover the several areas of physiology

and later revise periodically the individual volumes as need arises. Volume I of *Neurophysiology* is the first of the series to be published; two more volumes for this section are in preparation, as well as a section on the circulation. From any viewpoint the project is a monumental one that promises to fill the gap between the original literature and the standard textbooks of physiology. As this volume exemplifies so well, they will provide an authoritative overview of the subject that has been so difficult for an outsider to achieve while such rapid progress was being made.

The contents of this volume are: Historical development (Mary A. B. Brazier); Introduction to neuron physiology (J. C. Eccles); Conduction of the nerve impulse (I. Tasaki); Initiation of impulse at receptors (J. A. B. Gray); Synaptic and ephaptic transmission (H. Grundfest); Skeletal neuromuscular transmission (U. S. von Euler); Neuromuscular transmission in invertebrates (E. J. Furshpan); Introduction to brain potentials and rhythms (A. Fessard); Identification and analysis of single unit activity in the central nervous system (K. Frank); Intrinsic rhythms of the brain (W. G. Walter); Evoked potentials (Hsiang-tung Chang); Changes associated with forebrain excitation processes (J. L. O'Leary and S. Goldring); Epileptic seizures (H. Gastaut and M. Fischer-Williams); Introductions to sensory mechanisms (Lord E. D. Adrian); Non-photic receptors in lower forms (H. Autrum); Touch and kinesthesis (J. Z. Rose and V. B. Mountcastle); Thermal sensations (Y. Zotterman); Pain (W. H. Sweet); Taste (C. Pfaffmann); Smell (W. R. Adey); Vestibular mechanisms (B. E. Gernandy); Excitation of auditory receptors (H. Davis); Central auditory mechanisms (H. W. Ades); Introduction to vision (H. K. Hartline); Photosensitivity in invertebrates (L. J. and Margery Milne); Image-forming mechanism of the eye (G. A. Fry); Photoreceptor process in vision (G. Wald); Neural activity in the retina (R. Granit); Central mechanisms of vision (S. H. Bartley); and Central control of receptors and sensory transmission systems (R. B. Livingston).

Since every chapter is written by a different author, the result might have been just another symposium-like product. Several intentional features have avoided that outcome. Foremost, each individual author has been given a sizable topic to cover and has attempted to give perspective, a sound, conservative evaluation, and comprehensive coverage. In practice this must have been difficult to achieve; and for it the editors too must deserve commendation. To the same end each of the four major divisions is introduced by a senior individual. These articles vary in effectiveness, but Eccles' introduction, for example, does helpfully summarize the major aspects of his assigned subject with appropriate emphasis. Since the work is not primarily a textbook, the overall organization is not critical. The sequence is in part logical, beginning with a historical survey and proceeding to the neuron and junctions and later to the senses. The placement of assorted central phenomena before the senses seems odd, but not a serious matter.

The omission of certain important topics is a serious deficiency, and topics that would seem to belong in this volume are missing. Certainly a chapter on mechanoreceptors was warranted; instead, bits and pieces of this model system are mentioned in several chapters. The peripheral analysis of olfaction is slighted and even misrepresented. Tasaki, unfortunately, chose myelinated neurons as his model system; as a consequence the squid axon and the Hodgson-Huxley theory are in effect not discussed in the volume. Similarly, the electrophysiology of vision in *Limulus* and in the vertebrate retina (except for the ERG) are hardly mentioned. More important gaps than these would be difficult to arrange deliberately.

These criticisms hardly affect the obvious merit of the book as a whole; a better one is not likely to be published on this subject. The chosen contributors are among the most distinguished and competent in their subjects. No effort was spared to provide an attractive, efficient format and really fine illustrations. The index and references are generally adequate, although the titles of cited papers and their inclusive page numbers are not. Perhaps we shall soon have to become accustomed to such prices of books as $22.00 per volume. If they are justifiable for any, then this work is one of them.

DAVID R. EVANS

ANNUAL REVIEW OF PHYSIOLOGY. *Volume 22.* *Victor E. Hall, editor; Frederick A. Fuhrman and Arthur C. Giese, associate editors. Annual Reviews, Palo Alto.* $7.00. viii + 725 pp. + 1 pl.; text ill. 1960.

The regularly included subjects, and their authors in this volume are as follows: Kidney, water, and electrolytes (A. Leaf); Respiration (J. F. Perkins, Jr.); Heart (A. S. Harris); Peripheral circulation (J. M. Crismon); Alimentary tract (C. A. M. Hogben); Somatic functions (J. P. Segundo and C. Galeano); Visceral functions (F. P. Brooks); Higher functions of the nervous system (W. D. Neff and J. M. Goldberg); Nerve excitation and transmission (C. S. Spyropoulos and I. Tasaki); Adenohypophysis and adrenal cortex (W. F. Ganong and P. H. Forsham); and Reproduction (T. R. Forbes).

Less usual topics are: Nuclear-cytoplasmic interactions (D. M. Prescott); Physiological aspects of genetics (G. W. Beadle); Developmental physiology

(J. S. Nicholas); Comparative review of the fuel of muscle metabolism (G. I. Drummond and E. C. Black); Comparative physiology of blood pigments (C. Manwell); Visual physiology (F. Crescitelli); and The thyroid (D. H. Solomon and J. T. Dowling). The prefatory chapter is by F. C. McLean, who reminisces about the relationship between physiology and medicine during his career. The editors note that the chapter on blood volume regulation, by E. B. Reeve, T. H. Allen, and J. E. Roberts is a radical departure from the form of the usual review. It is a thorough and consistent attempt to formulate this aspect of physiology in mathematical terms. (It may be remarked that a similar ambitious effort concerning cardiovascular physiology was an article by Fred S. Grodins in the June, 1959, issue of the *Quarterly Review of Biology*.) Cumulative indices to authors and titles in Volumes 11 through 22 are also in this volume.

Volume 23, it is announced, will contain reviews of transport through biological membranes, aging, hearing, skin, liver, photoperiodicity, transmitter substances, energy metabolism, and skeletal muscle, along with the regularly reviewed subjects.

DAVID R. EVANS

PHYSIOLOGY OF MUSCULAR ACTIVITY. *Fifth Edition. By Peter V. Karpovich; originally by Edward C. Schneider. W. B. Saunders Company, Philadelphia and London.* $5.50. xviii + 368 pp.; ill. 1959.

A book that has gone into its fifth edition, as this one has, deserves to be called a classic. Indeed, there is none other exactly in its field. From its first edition, when the late Edward C. Schneider was its author, it has been directed primarily to students of physical education as a textbook on the mechanism of and physiological adjustments to exercise. In this area, Karpovich has kept the monograph up to date and I have no reason to doubt that, time-tested as it is, it is admirably suited to the restricted purpose for which it was designed.

With respect to its value for a larger audience, one must catalog some of its strengths and weaknesses. In the area of pure description of overall bodily responses to physical activity, this book supplies an excellent introduction and is enriched by a large and modern bibliography in the fields of work performance, work tolerance, limits of human endurance and performance, and so on. The fact is, of course, that in man it is not the skeletal muscles which limit performance but the cardiovascular and respiratory systems. For this reason Karpovich includes considerable emphasis on the responses of these systems. In the main, his descriptions of cardiovascular and respiratory adjustments are adequate, but he is grossly deficient in considering the work of breathing.

The book is on less solid ground in its discussion of the basic physiology and chemistry of muscle. In these areas it is not only not up to date, but perpetuates some of the old erroneous notions, for example, the relation of lactic acid to fatigue.

Karpovich interpolates aphorisms and what may be called clinical opinions, along with certain other pet ideas. Although these undoubtedly add flavor and personality to the book, I found them sometimes irrelevant and usually distracting.

KENNETH L. ZIERLER

MOLECULAR BIOLOGY. *Elementary Processes of Nerve Conduction and Muscle Contraction. A symposium sponsored by Columbia University and the Rockefeller Institute; held at The Rockefeller Institute from September 25th to 30th, 1958. Edited by David Nachmansohn. Academic Press, New York and London.* $7.50. xvi + 177 pp. + 14 pl.; text ill. 1960.

The stated aim of this symposium was to bring together persons representing diverse areas of knowledge to discuss the problems of nerve conduction and muscle contraction, primarily in an informal manner. The sixty or more participants constituted an unusually distinguished, diversified, and international group. This small book must represent only a small part of the symposium, presumably because it was so largely informal.

The contents are as follows: Structure of striated muscle (H. E. Huxley); Heat production of muscle and nerve (A. V. Hill); Chemical reactions during contraction and relaxation (H. H. Weber); Attempts toward a formulation of biological use of energy in terms of chemical potential (F. Lipmann); Structure and function in proteins (Barbara W. Low); Mucopolysaccharides of connective tissue (K. Meyer); Physical chemistry of nerve action (H. Eyring); Molecular biology of cell membranes (J. D. Robertson); Molecular basis of nervous activity (I. B. Wilson); and Physiological effects of sodium and guanidinium ions in the light of their electronic structure (L. Paoloni). Generally the articles are very brief, with the exception of Robertson's (65 pages).

DAVID R. EVANS

CHEMICAL AND MOLECULAR BASIS OF NERVE ACTIVITY. *By David Nachmansohn. Academic Press, New York and London.* $7.50. xii + 235 pp.; ill. 1959.

For more than two decades Nachmansohn has been engaged in research in neurophysiology, especially

its biochemical aspects. Much of his early work was devoted to the study of acetylcholine, at a time when its role as a junctional transmitter was hotly debated. More recently he has studied and championed another viewpoint that has also evoked controversy. In general, he holds that the ionic conductance changes that produce the action potential in excitable cells must be brought about by a "chemical reaction" (that the longer-term maintenance of ionic gradients depends on metabolic energy is acknowledged by all). Other neurophysiologists often say nothing about the mechanism of these changes or tend toward a physical explanation. Nachmansohn's more specific and more controversial proposition is that acetylcholine (ACh) is the factor that produces the permeability changes in the axon as well as elsewhere. It is to develop and defend these propositions that this book was written, though, of course, in so doing the author covers a great deal of material that is valuable in other ways.

Chapter 1 argues that (1) the initial heat of nerve during conduction and (2) the temperature coefficient of spike duration require that a chemical process be responsible. This crucial point is all too briefly developed, considering the effort expended on lesser topics. The argument continues some pages later by presenting the evidence that *specific* inactivation of acetylcholinesterase by inhibitors is paralleled by a reduction and final abolition of the propagated potential. More recent, similar experiments are described in which analogs of ACh that were made to permeate the nerve by attaching detergent-like side-chains were found to mimic at low concentrations the action of acetylcholinesterase inhibitors, *i.e.*, to depolarize and thereby block conduction. All of these and other salient data are presented in detail, but one had better look elsewhere for the objections and data of the critics of this view. Chapter 6 summarizes the resultant hypothetical scheme: a stimulus releases bound ACh, which then may react reversibly with a receptor molecule or may be split by acetylcholinesterase. Combination with the receptor alters its configuration, and thereby results in increased sodium conductance. This new presentation of theory and these new data will probably not alter materially the verdict of opponents' regarding this role for ACh: the verdict "not proved."

Actually, the bulk of the book is not directly related to the above considerations, though it is almost entirely a report for many years of research by the author and his collaborators. The content in essence is "all about ACh": its synthesis via choline acetylase; attempts to isolate the ACh receptor molecule from electroplax; ACh distribution and concentration; and acetylcholinesterase localization, activity, and properties. Cholinesterase is an interesting enzyme if only because neurophysiologists, pharmacologists, histochemists, and biochemists all willingly study it. And the penetrating studies of this enzyme by I. B. Wilson have produced a fundamental understanding of its reaction mechanism and the nature of its active site.

The last three chapters can be taken as a final, presumably sincere thrust at Nachmansohn's critics, almost all of whom accept the proposition that ACh is a junctional transmitter. Evaluating the evidence for this seeming truism, Nachmansohn suggests that perhaps, after all, the release of ACh at neuromuscular junctions is only incidental to its primary action, and that perhaps its role is *only* intracellular and not at all intercellular.

DAVID R. EVANS

AUTONOMIC IMBALANCE AND THE HYPOTHALAMUS. *Implications for Physiology, Medicine, Psychology, and Neuropsychiatry.*

By Ernest Gellhorn. University of Minnesota Press, Minneapolis. $8.50. xiv + 300 pp.; ill. 1957.

This book can be read on two levels: It is both a highly technical report on experimental work and a deeply moving attempt to cross the ever-widening gulf between the sciences and the humanities. The author is well equipped to write on both levels. As a brilliant experimental neurophysiologist he has been aware for many years of the task of neurophysiology in explaining the mind, or, in other words, aware of the deep philosophical implications of his chosen field. The experiments described in this monograph had their origin in clinical observations that the intensity of the action of the drug mecholyl showed greater variations in neuropsychiatric patients than in "normal" controls. The main action of mecholyl is to reduce blood pressure. These observations suggest to the author the possibility of measuring the excitability of the hypothalamus in the intact organisms through changes in the autonomic balance. This was accomplished in most experiments by changing the blood pressure through the action of drugs. All of the author's experiments were performed on cats. They are described in great detail and illustrated with graphs. The book is warmly recommended to neurophysiologists, psychologists, and psychiatrists.

W. FLEISCHMANN

THE FUNCTIONS OF THE ENDOCRINE GLANDS.

By Peter Hall. W. B. Saunders Company, Philadelphia. $5.75. xviii + 290 pp.; ill. 1959.

The author has tried to condense our present

knowledge of endocrinology into one small volume. If one considers the recent progress in this field, he will not be surprised that the author has not been entirely successful. However, he has managed to compile a review which can well serve as a useful outline of study for an undergraduate course. The discussion of the chemistry of the hormones is the best part of the book. The discussion of endocrine diseases, so vital for the understanding of endocrinology, is too brief to be useful. Despite its shortcomings in the field of clinical endocrinology, Hall's book can be recommended as a first introduction to general endocrinology.

W. FLEISCHMANN

VITAMINS AND HORMONES. *Advances in Research and Applications. Volumes XVI and XVII.*

Edited by Robert S. Harris, G. F. Marrian, and Kenneth V. Thimann. Academic Press, New York and London. (Vol. XVI) $11.60; (Vol. XVII) $14.00. (Vol. XVI) xii + 437 pp.; ill. 1958. (Vol. XVII) xii + 359 pp.; ill. 1959.

Volume 16 contains chapters with the following titles and authors: Nutritional effects of parasitic infections and disease (Q. M. Geiman); Dependence of gonadal function upon vitamins and other nutritional factors (C. Lutwak-Mann); Chemical structure in relation to biological activities of vitamin B_6 (E. E. Snell); Vitamins and other nutrients in cardiovascular disease (W. C. Felch, L. Sinisterra, T. B. van Itallie, and F. J. Stare); Hormonal aspects of coronary artery disease (M. F. Oliver and G. S. Boyd); Physiology of secretin (M. I. Grossman); Chemistry and physiology of the thyroid-stimulating hormone (M. Sonenberg); Glucagon (O. K. Beherns and W. W. Bromer); and Synthetic derivatives of cortical hormones (J. Fried and A. Borman.) In addition, there is a cumulative subject index to Volumes 11 to 15; subject and author indices to the current volume are also provided.

Volume 17 contains the following reviews: Metabolism of folic acid and other pterin-pteridine vitamins (S. H. Hutner, H. A. Nathan, and H. Baker); Chemistry and biochemistry of the K vitamins (O. Isler and O. Wiss); The role of hepatic glucose-6-phosphatase in the regulation of carbohydrate metabolism (J. Ashmore and G. Weber); Biochemistry of serotonin and other Indoleamines (S. Udenfriend); Ergothioneine (D. B. Melvills); Mechanisms of action of estrogens (L. L. Engel); Atherosclerosis and toxemia of pregnancy in relation to nutrition and other physiologic factors (L. M. Dalderup); and Progestational agents and the control of fertility (G. Pincus). There are also the usual indices to author and subject.

THE MICROCIRCULATION. *Symposium on Factors Influencing Exchange of Substances Across Capillary Wall. Proceedings of the Fifth Conference on Microcirculatory Physiology and Pathology, Buffalo, New York, April 1, 1958.*

Edited by S. R. M. Reynolds and Benjamin W. Zweifach. The University of Illinois Press, Urbana. $4.50. viii + 170 pp. + 7 pl.; text ill. 1959.

The contributions to this symposium are as follows: The fine structure of capillaries, arterioles and small arteries (D. W. Fawcett); Capillary permeability and transcapillary exchange in relation to molecular size (E. M. Renkin); Macromolecular exchanges in capillaries (L. Sapirstein); Properties of artificial membranes with microscopic pores (J. Arnold); The relationship in diabetes mellitus of abnormal vasomotor patterns in the smaller blood vessels to retinopathy and nephropathy (J. Ditzel); Pulmonary microcirculation of living rabbits during passive anaphylaxis (J. W. Irwin, S. Weille, I. M. York, M. A. Rappaport); Relations between size and distribution of "spontaneous" metastases and intravenously injected particles of XV_2 carcinoma and anatomy of pulmonary vessels (W. H. Knisely and M. S. Mahaley, Jr.); Microcirculation in the intramural vessels of the small intestine in the rat (S. Baez); A study of lymphatic permeability to albumin (H. S. Mayerson); Electronic image processing of peripheral vascular beds (M. C. Brown and L. Warner); Structural and functional aspects of the microcirculation in the skin (B. W. Zweifach); list of members; and subject index.

LEUKOCYTE ANTIGENS AND ANTIBODIES.

By Roy L. Walford. Grune & Stratton, New York and London. $6.75. x + 182 pp.; ill. 1960.

This book is concerned chiefly with circulating antibodies against leukocyte antigens, but not with the role of leukocytes in the formation or transport of antibodies. After a brief description of the techniques used, the following problems are discussed: isoantigens and antigenic differences of leukocytes, antileukocyte antibodies, leukoagglutination, drug reactions involving leukocytes, the lupus erythematosus factor, and the significance of leukocyte antibodies in homograft reactions and in clinical medicine. The book contains 567 references and is written very critically. Since the interpretation of the observed phenomena is frequently contradictory, the author considers it to be occasionally "worthwhile to examine the data in a hypercritical fashion" and then gives his own view. Problems of general biological interest are only

rarely discussed. The book will, however, be of great value to hematologists and to physicians or health officers who have to perform blood transfusions.

F. HAUROWITZ

THE PHARMACOLOGY OF PLANT PHENOLICS. *Proceedings of a Symposium held at Oxford, April, 1958. Edited by J. W. Fairbairn. Academic Press, New York and London.* $6.00. x + 151 pp.; ill. 1959.

This volume is a report of a symposium held under the auspices of "The Plant Phenolics Group." This is an informal group of chemists and biologists organized with the object of promoting "the advancement of knowledge of phenolic and related constituents of plants in respect to their chemistry, function, biosynthesis, effect on plant and animal physiology and pathology, and the application of such knowledge in agriculture and industry." The eleven papers brought together in this volume express the breadth of interest of this group and show that the purposes of the organization, as expressed in the previous sentence, are being promulgated.

The authors of papers were asked to exclude reference to nitrogen-containing phenolics, such as alkaloids. One exception is the opening paper on Some Important Phenolic Compounds in Pharmacology, by J. H. Burn, which deals mostly with adrenaline, noradrenaline, 5-hydroxytryptamine, and a few related compounds. Other topics discussed were: The fate of phenolic compounds in the body (R. T. Williams); The toxicity of plant phenolics (W. B. Whalley); The cathartic action of anthraquinones (W. Fairbairn); Plant phenolics possessing oestrogenic activity (J. D. Biggers); Photodynamic compounds in plants (J. D. Biggers); Capillary structure and action of flavonoids (M. F. Lockett); Physiological effects and metabolic fate of flavonoids (F. DeEds); Problems posed by the activity of certain flavonoids on vascular resistance (J. Lavollay and J. Neumann); The bactericidal action of certain phenolics of grapes and wine (J. Masquelier); and Plant phenolics in foods (E. C. Bate-Smith).

As can be seen from these titles, a large part of the symposium was devoted to the bioflavonoids. Originally, some of these compounds were held to have vitamin-like activity, but this is no longer accepted. However, these agents are being extensively used medicinally because of their beneficial effects on capillary fragility, and the three papers dealing with this subject add valuable new data to our knowledge of these interesting compounds. Each chapter is followed by an edited version of the discussion which followed the paper, with the names of each person participating. This is an especially attractive feature of the book.

The book is beautifully printed on durable paper, and the structural formulas, diagrams, tables, and illustrations are clearly drawn, neatly printed, and attractively arranged for easy reading. The editor is to be congratulated for the fine job he has done in assembling these valuable papers in a most attractive style. The book will appear to everyone who shares the interests of "The Plant Phenolics Groups" and to others who may have only an interest in some particular aspect of this ubiquitous class of natural products.

JOHN C. KRANTZ, JR.

BIOPHYSICS AND GENERAL PHYSIOLOGY

A TEXTBOOK OF GENERAL PHYSIOLOGY. *Second Edition.*

By Hugh Davson. Little, Brown & Company, Boston. $14.50. xvi + 846 pp. + 32 pl.; text ill. 1959.

If the vitality of a scientific field be judged by the changes that become necessary in successive editions of a textbook, general physiology is in a rapid state of development, and this development is elegantly reported in the second edition of what I have always considered the best available book. Davson comments in his Preface that he has been unable to circumvent the "law of growth of textbooks," which states that these increase exponentially with time; indeed, the current edition appears almost twice as large as the first. Even more serious, the price of the book has risen to an extent such as to put it out of the reach of many potential readers. It may be suggested that, in future editions, the subject matter may be further limited by a more strict definition of the field of general physiology. In the present edition more than half the pages (430 pp.) have to do with membrane phenomena such as molecule and ion equilibria in cells, active transport in tissues, and electrophysiological phenomena. The balance of the pages is devoted to: ultrastructure (120 pp.), energy transformations (60 pp.), contraction (55 pp.), and light (100 pp.). The section on energy transformations is much more extensively treated in books on biochemistry and mammalian physiology, and it hardly seems worthwhile dealing with these in such an abbreviated form. The other sections discuss physiological phenomena in a much more detailed and satisfying way. Three new chapters in this edition are entitled: The sensory response; Excitability of cardiac muscle; and Electrical activity of smooth muscle. These are all welcome additions to the "membrane phenomena"

section of the book, and each chapter is well supplied with an extensive bibliography of the field.

The revisions that have been made in the book are most impressive. There is a liberal use of fine electron micrographs throughout. Much of the electrophysiology has had to be extensively revised in order to present the voltage clamp data obtained with squid axons, and the general field of ion transport has expanded so greatly that a great deal more in the way of quantitative presentation is now possible. Such comments apply equally to other fields that are discussed, and one has the impression that the bibliography has been thoroughly modernized.

L. J. MULLINS

BIOCHEMISTRY

PROGRESS IN THE CHEMISTRY OF ORGANIC NATURAL PRODUCTS. *Volume 17.*

Edited by L. Zechmeister. Springer-Verlag, Wein. $19.80. x + 515 pp.; ill. 1959.

Volume XVII of this well-known series on organic natural products contains again a number of excellent articles. The reviewer was particularly impressed by two reports. One of them is a masterful survey by K. Venkataraman on flavons and isoflavons, their occurrence, properties, absorption spectra, and biosynthesis. The other is a progress report on D vitamin derivatives, written by one of the pioneers in this field, H. H. Inhoffen, and K. Irmscher. The structures of praecalciferol, tachysterol, lumisterol, the suprasterols, and other derivatives formed by the irradiation of provitamin D are certainly of high interest to biochemists and biophysicists. The article closes with a description of the total synthesis of vitamin D_3 accomplished by Inhoffen in 1958. From the review by F. Korte et al. on bitter principles in plants, we learn that bitter substances have very different chemical constitutions, and that next to nothing is known regarding correlations between bitter taste and chemical structure. In a subsequent article, K. Bernauer reports on the alkaloids of curare and South American strychnos types, and on their biosynthesis from tryptamine and prephenic acid. The occurrence and metabolism of simple indoles in plants is treated in a review article by B. B. Stowe. A. E. Diamond, in a short report on the biochemical aspects of disease in plants, intends "to stimulate curiosity, not to satisfy it." The same might be said about P. H. Abelson's article on paleobiochemistry and organic geochemistry. Recent progress in the chemistry of the normal human hemoglobins is described in an excellent critical review by W. A. Schroeder, to whom we owe important contributions in this field. In the last article H. Kuhn amplifies an earlier report on his interesting electron gas theory of the color of natural and artificial dyes. The volume is recommended to chemists, biochemists, and biologists as an invaluable source of information about material which is widely scattered in the literature and is presented here by highly competent reviewers in a systematic manner.

F. HAUROWITZ

ADVANCES IN CARBOHYDRATE CHEMISTRY. *Volume 14.*

Edited by Melville L. Wolfrom; assoc. ed., R. Stuart Tipson. Academic Press, New York and London. $15.00. xii + 525 pp. + 1 pl.; text ill. 1959.

Like the previous volumes of this series, Volume 14 of the *Advances in Carbohydrate Chemistry* continues to serve as an authoritative source of information for chemists and biochemists on the progress of the ever-expanding field of carbohydrate chemistry. It presents 7 reviews of specialized topics in the field.

The opening chapter, entitled The Action of Lead Tetraacetate on the Sugars, by Perlin, is a discussion of the applicability of this reagent to carbohydrate studies. Lead tetraacetate has the ability to cleave oxidatively 1,2-glycol groups, and is especially suitable for differentiating between the various kinds of groups. This reaction, together with the closely related periodate reaction, has proved to be a most useful tool for carbohydrate research during the last three decades.

The article on The Maillard Reaction, by G. P. Ellis, gives a detailed account of the present status of the so-called browning reaction, which involves the interaction of the amino group of amino acids, peptides, or proteins with the glycoside hydroxyl group of sugars. Because of the significance of this reaction in the preservation of various foodstuffs, the work on the browning reaction has been reviewed a number of times in *Advances in Food Research* and other publications.

The chapter on The Cyclitols (a group of compounds which includes the inositols, guercitols, inosamines, and their derivatives) by S. J. Angyal and L. Anderson, is a continuation of the 1948 review by Fletcher of this type of compound. During the last decade most of the immediate problems of this group of substances have been solved. These include: the synthesis of the hitherto unknown inositol diastereomers, the total synthesis and the synthesis from D-glucose, the discovery of four new inositol methyl ethers in plants, and the discovery of inosamines in nature. These new developments have been well covered in this chapter.

The Chemistry of the Amino Sugars, by A. B.

Foster and D. Horton, reviews the recent progress made in the discovery of a variety of complex substances containing new amino sugars. Interest in amino sugars has grown considerably over the past two decades with the recognition that biologically active mucopolysaccharides and mucoproteins such as heparin, blood group specific substances, virus hemaglutinin inhibitors, and gonadotropins contain N-substituted 2-amino-2-deoxy sugars. Moreover, sialic acids, containing an amino sugar as a central constituent, proved to be integral components of mucoproteins and some mucolipides of animal origin and as constituents of certain bacterial membranes.

Although the topic of nucleic acids has been reviewed more than once in this series, the extraordinary activity and interest in this area of carbohydrate investigation have prompted the editors to present further reviews on this subject. Pyramidine Nucleosides, by J. J. Fox and I. Wempin, is part of a projected series of chapters covering subdivisions of this rapidly expanding subject.

G. A. Levvy and C. A. Marsh, in their article Preparation and Properties of β-glucuronidase, discuss the physiological activity of this enzyme which is universally distributed in mammalian tissues and body fluids. Its primary function appears to lie in mucopolysaccharide catabolism. The enzyme finds its major application as a reagent for hydrolysis of steroid D-glucuronides.

In this chapter on the Structural Chemistry of the Hemicelluloses, G. O. Aspinall reviews the advances made during the last ten years in solving certain problems of the chemical constitution of hemicelluloses found in great abundance in higher plants. The author uses the term "hemicellulose" to include those plant cell-wall polysaccharides which occur in close association with cellulose. He is chiefly concerned with three main groups of these polysaccharides, namely, those based on chains of D-xylone, D-mannose (either alone or in association with D-glucose), and D-galactose residues.

This volume also contains an obituary of the late noted Hungarian carbohydrate chemist, Géza Zemplin.

In addition to the usual index, Vol. 14 contains an author and subject cumulative index to the previous 13 volumes.

W. Z. Hassid

LIPIDE CHEMISTRY.

By Donald J. Hanahan; with contributing chapters by Frank R. N. Gurd and Irving Zabin. John Wiley & Sons, New York and London. $10.00. x + 330 pp.; ill. 1960.

The recent increased interest in lipides has produced a need for a textbook for courses on lipides at the graduate level. A portion of the subject matter of this volume has been used as lecture material for a graduate course in lipide biochemistry by D. J. Hanahan. There is an introductory chapter on the chemistry and metabolic behavior of the major lipide classes. This is followed by chapters on the Isolation and Purification of Lipides, Phosphoglycerides, Phosphoinositides, Sphingolipides (Zabin), Minor Phospholipides, Simple Lipides, and finally two chapters by Gurd entitled, Association of Lipides with Proteins and Some Naturally Lipoprotein Systems. These last two chapters constitute about one-third of the volume.

All of the chapters are excellent, and each is concluded with adequate references to the literature. Current investigative problems are stressed throughout, and the treatment is concise and authoritative. This volume will serve admirably as an an introduction to the field of lipide chemistry for graduate students and for others in biology and medicine who wish to become acquainted with the current stage of development in this difficult field. A companion volume entitled *Lipide Metabolism*, edited by Konrad Bloch, is in press.

C. R. Treadwell

BIOCHEMIE DER HORMONE.

By Theodor Bersin. Akademische Verlagsgesellschaft, Leipzig. DM 27. viii + 342 pp.; ill. 1959.

For students and teachers of biochemistry or biology, this is a useful source of information and references on animal hormones, both vertebrate and invertebrate. It is impressive to be reminded here of how much we have learned in the past fifteen years about the structure and mode of action of the hormones. Particularly impressive, of course, is the elucidation of the structure and amino acid sequence of the protein and peptide hormones. Also very striking is the great advance in our knowledge of the basic mode of action of hormones and, more important, the great change in our point of view in the study of these problems. This new point of view is emphasized by the author, who actually defines hormones as regulators of metabolism, thereby stressing the point that one can no longer rest content to describe the action of any hormone in terms of morphological changes or to limit one's studies to a consideration of the effects of hormones on intact organisms or cells. There are now so many well-documented cases of hormone action in cell-free systems that it is difficult to believe that as recently as fifteen years ago the view was generally held that hormone action could be demonstrated only in the presence of an intact cell structure.

Bersin's book is divided into three parts. The first part (90 pp.) deals with general properties of the hormones of the animal world and of humans;

the second part (200 pp.) deals with each of these hormones individually; and the third part (28 pp.) considers the general significance of the hormones.

Part I is too brief to be very useful as a treatment of the general properties of the hormones, but it does contain a useful section on the different types of chemical structures for hormones encountered in vertebrates and invertebrates, including insects. In this section there is a valuable review of steroid chemistry and configuration. The other sections of Part I deal with the preparation, assay, biological properties, and practical uses of hormones in terms which are too general to be particularly valuable.

Part II is also general in nature, dealing with such topics as the hormonal regulation of embryonic growth, hormone-vitamin relationships, hormone-hormone relationships, hormones in relation to the nervous system, and hormones in relation to aging. The treatment of such a broad spectrum of subject matter in so few pages must of necessity be superficial.

The most useful part of the book is the large second part, which includes, to varying degrees for each hormone, a brief historical background, an account of the methods of isolation and synthesis, the method of bioassay, the chemical structure and properties, the relation of chemical constitution to activity, the mechanism of action, the histology of the secretory gland, the role of the hormone in physiology, the alterations in hormonal regulation occurring in disease, and the chemistry and action of synthetic substitutes for the hormones. This material is presented in a well-organized fashion and is reasonably up to date, including the literature through 1957 with some 1958 references. The references, which appear conveniently at the bottom of each page, must total well over 1000. The coverage of the literature is international and points up the resurgence of European biochemistry since World War II. It came as something of a revelation, at least to me, that many of the recent advances in hormone research which in the United States we tend to regard as "100 per cent American" were actually made simultaneously by European scientists with smaller staffs and smaller resources, but with perhaps greater resourcefulness.

One cannot help noting, however, that there seems to be some prejudice on the part of the author in his coverage of the literature. The author index contains 21 references to himself, equal to the total number of references allotted to C. F. Cori, Houssay, Reichstein, Butenandt, and Du Vigneaud. In some cases, important results are cited but no reference is given. For example, the enzymatic basis of the glycogen storage diseases is discussed without reference to G. T. Cori. In other cases, investigators are cited by name only, and no reference is given to the literature.

There is some tendency for the author to be overly dogmatic, as when he states that the only reserve material of the animal and plant organism is fat, or when he concludes from tracer data that sugar can be formed from fat to a large extent in the animal body. There is also a tendency in some places to be uncritical with respect to selection of material. On the whole, however, the book is reliable and remarkably thorough in its presentation of facts, formulae, and metabolic schemes, and it presents a well-rounded picture of the modern approach to studies on the hormones.

SIDNEY P. COLOWICK

CHEMIE UND STOFFWECHSEL VON BINDE- UND KNOCHENGEWEBE. *7. Colloquium der Gesellschaft für physiologische Chemie in Mosbach/Baden, am 12.–14. April 1956.*

Springer-Verlag, Berlin. DM 19.80 (paper). 142 pp.; ill. 1956.

This symposium contains six papers, all in German in spite of the very international selection of participants. F. Wassermann, of the Argonne National Laboratory, opened with a discussion of the structural bases of the chemistry and metabolism of supporting tissues. There followed reviews of the mucopolysaccharides and glycoproteins of connective tissue, by E. Jorpes and I. Yamashina (Karolinska Institute); of certain interesting phenomena in the physiology of connective tissue, by L. E. Glynn and C. A. Reading (England); of the metabolism of bone tissue, by E. Schütte (Berlin); of epithelial bodies and bone tissue, by F. C. McLean (University of Chicago); and finally, of the influence of vitamins upon calcification, by O. Hövels (Erlangen). The general discussion which followed each of the main papers is included, and there are some good illustrations; but there is no index. The simple paperbacked format is to be recommended for brief symposia such as this one, but the price, close to $5.00 in U. S. currency, is hardly what one would expect even nowadays.

BENTLEY GLASS

THE ENZYMES. *Volume 1. Kinetics, Thermodynamics, Mechanism, Basic Properties. Second Edition.*

Edited by Paul D. Boyer, Henry Lardy, and Karl Myrbäck. Academic Press, New York. $24.00. xiv + 785 pp.; ill. 1958.

When the reviewer was embarking on graduate studies some twenty-five years ago, the statement that urease was a protein was still regarded as de-

batable. This first volume of the new edition of "Sumner-Myrbäck" bears witness to the speed and extent of developments in our knowledge of the enzymes—a group of substances recognized mainly as mysteries at a period that many of us recall quite clearly. There is, fortunately, plenty of the unknown left in enzymology, and quite enough mystery to challenge the curious. One must admit, however, that the subject is no longer an infant, but rather a vigorous adolescent—old enough to be getting both reliable and respectable.

One can gauge one type of scientific respectability by the extent to which the mathematicians and physical scientists are willing to take over. By such a criterion, enzymology is becoming impressive indeed, as the list of contributors to this volume can show. Fourteen articles cover the general topics included in the subtitle. Most of the authors are playing leading roles in the current developments of their areas of specialization, and a not inconsiderable proportion of them are professors of chemistry rather than of biochemistry.

As pointed out by the editors, the subject matter of this second edition is so thoroughly revised that the book should be regarded as a supplement rather than a substitute for Volume I of the first edition. To drive home this point, one may mention that the only article which contains more than a small sprinkling of references dated prior to 1950 is the first chapter, which develops the subject of enzyme kinetics from a historical point of view. In subsequent chapters, enzyme kinetics are handled in detail for those who have a taste for the mathematical approach. The great bulk of the volume is concerned, however, with the chemical mechanisms of enzyme action or with those aspects of enzyme chemistry which have a bearing on the problem of mechanism. The chapters and their contributors are as follows: The development of enzyme kinetics (H. L. Segal); Enzyme kinetics (J. Z. Hearon, S. A. Bernhard, S. L. Friess, D. J. Botts, and M. F. Morales); The rate equation for an enzymic reaction (R. A. Alberty); Some aspects of the thermodynamics and mechanism of enzymic catalysis (R. Lumry); Structural and stereospecificity (H. Gutfriend); Enzyme models (F. H. Westheimer); Mechanisms of transfer enzymes (D. E. Koshland, Jr.); Electron transfer and enzyme catalysis (P. George and J. S. Griffith); Coordination, chelation, and catalysis (R. J. P. Williams); Protein structure and enzyme activity (K. U. Linderstrøm-Lang and J. A. Schellman); Sulfhydryl and disulfide groups of enzymes (P. D. Boyer); Other reactive groups of enzymes (H. Fraenkel-Conrat). The more biological aspects of the subject are covered in two final chapters: Induced formation of enzymes (M. R. Pollock); and The control of enzyme activity (A. B. Pardee).

Although there are some chapters in this volume which can be read with pleasure by anyone trained in general biochemistry, there are probably few biochemists who have a sufficiently broad background to read all of the articles with ease. The book is nevertheless recommended for browsing as well as for reference. If the remaining volumes meet the high standards set in Volume I, this will be an indispensable reference set for anyone engaged in enzyme studies.

BIRGIT VENNESLAND

BEHAVIOR OF ENZYME SYSTEMS. *An Analysis of Kinetics and Mechanism.*

By John M. Reiner. Burgess Publishing Company, Minneapolis. $6.50. xii + 317 pp.; ill. 1959.

The stated purpose of this book is to provide some explicit guidance into the mathematical aspects of enzyme action for those research workers who feel the need for quantitative interpretations of their work, but whose mathematical training is not exactly confidence-inspiring. The book is supposed to make it possible for anyone to begin knowing substantially nothing and to finish it an expert in enzyme kinetics—for this is the only aspect of the behavior of enzymes treated in detail. Obviously, then, this is not a book for the casual reader. Like all excursions into mathematics on the do-it-yourself basis, exploration of this book requires character and perseverance, as well as pencil and paper. The very explicitness of the mathematical derivations tends, at times, to dull the senses. Those, however, who can overcome these psychological hurdles will be rewarded not only with increased understanding of the course of enzyme reactions, but also with some delightfully candid observations on the scientific scene and many little gems of wit hidden among the formulae.

Besides the mathematical derivations of the usual kinetic equations, the author has presented good discussions of the analysis of complex biological systems, the effects of endogenous activators and inhibitors on the kinetics of enzymic reactions, as well as on linked reaction systems such as are found in the intact cell. This is a rather unique feature of the book, and should be enlightening to "experts" and novices alike.

I. D. RAACKE

PRINCIPLES OF DAIRY CHEMISTRY.

By Robert Jenness and Stuart Patton. John Wiley & Sons, New York; Chapman & Hall, London. $8.75. viii + 446 pp.; ill. 1959.

This book portrays a changing concept of "dairy chemistry." Early books with that title were de-

voted to the details of procedures for the analysis of milk and its products. This book merely outlines the principles upon which analytical methods are based and then goes on to other things, for the dairy chemist of today is concerned with many problems other than the control of composition. He must know much about the chemistry of proteins in general and about milk proteins in particular. He must know much about the chemistry of fats and carbohydrates, about enzymes and colloids. He must try to understand the complex equilibria and interactions which occur in milk and its products.

All of this information is needed in order to protect the appearance, the flavor, and the nutritional value of milk. But this requires, in addition, that we know as much as possible about flavor and the nutritional requirements of man. This book was written as an answer to these greatly expanded needs; it is not a text on milk analysis.

The book is written from the viewpoint of the organic chemist. Without some knowledge of organic chemistry, much of the text would be unintelligible. On the other hand, it requires no prior knowledge of milk research. For that reason, it may be considered an introductory text, but it was not written for freshmen.

Because it is an introductory book, limited to about 400 pages, it does not give an exhaustive treatment of the many subjects it covers. Graduate students and research workers may be disappointed with its treatment of their own specialties, but they will still prize the book because of the great quantity of general information it contains concerning milk and its constituents, information which would be difficult to find elsewhere.

The book contains very little about milk products or their manufacture. For example, under "cheese," the index has only two entries: "flavor of" and "nutritional value of." Each chapter is followed by a list of Selected References to guide those seeking additional information about special topics. Our European friends may be annoyed because no reference is made to publications in foreign languages. However, such references would be of no value to the students for whom the book was written.

The book is well printed, illustrated with many tables and graphs, and it is well indexed. It should prove invaluable to those who need information about milk and the constituents of milk. Such a textbook has been needed badly by those who teach upper classmen in dairy technology. Although it was not intended as a reference book, it will be used by many for that purpose until a better reference book is written.

B. L. HERRINGTON

ADVANCES IN CLINICAL CHEMISTRY. *Volume 2. Edited by Harry Sobotka and C. P. Stewart. Academic Press, New York and London.* $12.00. xiv + 387 pp.; ill. 1959.

This is the latest addition to one of the newest *Advances* series. "The material for this volume has again been selected with the object of presenting a cross section through the growing points of clinical chemistry." The volume provides critical accounts of six selected topics: Paper electrophoresis; principles and techniques (H. Peeters); Blood ammonia (Samuel P. Bessman); Idiopathic hypercalcemia of infancy (John O. Forfar and S. L. Tompsett); Amino aciduria (E. J. Bigwood, R. Crokaert, E. Schram, P. Soupart, and H. Vis); Bile pigments in jaundice (Barbara H. Billing); and Automation (Walton H. Marsh).

The first chapter is the longest one (132 pages) and gives an excellent review of the principles and techniques of both one- and two-dimensional methods of paper electrophoresis. Consideration of the new possibilities describes the trend of electrophoretic methods and indicates their possible development in the future.

S. P. Bessman's chapter on blood ammonia presents a concise report of the newer findings on ammonia metabolism. Existing techniques for the determination of blood ammonia are beset with difficulties and limitations, which still continue to obscure the significance of blood ammonia in numerous clinical syndromes in which ammonia metabolism probably plays a dominant role.

The synopsis on idiopathic hypercalcemia of infancy is particularly valuable to North American readers because this intriguing disease appears to be very uncommon in the United States and Canada. The disease has a wide interest, to the nutritionist, to the epidemiologist, to those interested in preventive medicine, to the radiologist, and the pathologist. Much of this interest stems from the unknown etiology of the disease and from the light which it may throw on the metabolism of vitamin D.

The scope of the chapter on amino-aciduria refers essentially to the quantitative excretion of free amino acids in both normal subjects and in a wide variety of diseases.

The review on bile pigments covers research findings since 1956, when it was demonstrated that the main pathway of bilirubin excretion is by conjugation with glucuronic acid. A more complete understanding of some of the defects in bilirubin metabolism which will cause jaundice is now possible, and these are discussed in this chapter.

The Automation chapter presents eight activities generally found in clinical chemistry laboratories in which a certain amount of automation exists: glassware washing; filtration and centrifugation;

pipetting and transferring: titration and buretting; mixing, agitating, shaking; weighing; evaporation and distillation; and colorimetric reading and recording of results. The *Analmatic* (Analmatic, Baird, & Tatlock (London) Ltd., Chadwell Heath, Essex, England) and the *Autoanalyzer* (Autoanalyzer, Technicon Instruments Corp., Chauncey, New York) systems of automatic chemical analysis are described.

The reviews are authoritative and possess extensive bibliographies.

EUGENE W. RICE

MEDICINAL CHEMISTRY. *A Series of Reviews Prepared Under the Auspices of the Division of Medicinal Chemistry of the American Chemical Society. Volume IV.*

Edited by F. F. Blicke and R. H. Cox. John Wiley & Sons, New York; Chapman & Hall, London. $12.00. x + 334 pp. 1959.

Volume IV of this series is concerned with the barbituric acid hypnotics. In keeping with the goals of medicinal chemists to provide comprehensive and systematic summaries of the chemical and biological properties of groups of pharmacologic agents, this book provides a correlation of these data on the "barbiturates." The scope of the review includes the history, synthesis, chemical conversions, and identification and quantitative determination of the barbituric acid derivatives. A comprehensive discourse is given on the pharmacology of the barbiturates, their distribution, metabolism, potentiation, and antagonism. The problems of tolerance, habituation, chronic intoxication, and addiction are reviewed briefly.

Tables have been prepared of the dissociation constants of 32 barbiturates, 55 salts or compounds, and the physical properties and distribution coefficients of a number of derivatives. An additional table cites the structure and references to fifteen 5-R-5R′-barbituric acid, 1-phenyl-2,3-dimethyl-4-dimethylamino-5-pyrazolone compounds. Very useful tables are presented giving the alphabetical listings of the generic names and trade names of a large number of these drugs.

The major portion of the text is devoted to a tabular classification of the barbituric acids based upon references cited in *Chemical Abstracts* (1907 through 1956) and *Chemische Zentralblatt* (1897 through 1944 with the exception of years 1940 through 1943). In addition, over 200 barbituric acid derivatives were reviewed that were tested at the I. G. Farbenindustrie plant at Elberfeld, Germany. A formula index is included and 1204 references are cited.

The author has skilfully completed a worthwhile task, and medicinal chemists and pharmacologists are indebted to him, for he has been able to achieve the aim established for the medicinal chemistry review series.

C. JELLEFF CARR

THE CHEMISTRY AND CHEMOTHERAPY OF TUBERCULOSIS. *A Compilation and Critical Review of Existing Knowledge on the Chemistry of Tubercle Bacilli and their Products, Chemical Changes and Processes in the Host, and Chemical Aspects of the Treatment of Tuberculosis.*

By Edmond R. Long. The Williams & Wilkins Company, Baltimore. $12.00. xviii + 450 pp.; ill. 1958.

Long's fine book, now in its third edition, succeeds in bringing together results from recent investigations into the chemistry of tubercle bacilli, chemical changes within tuberculous hosts, and an up-to-date report on chemotherapy in tuberculosis.

This book is a valuable source of reference for investigators in all fields of tuberculosis. Written with a very readable, concise precision, the text provides an accurate, clear picture of the current status of research within the three represented fields of investigation.

ROBERT C. PARLETT

THE CHEMISTRY OF ORGANIC MEDICINAL PRODUCTS. *Fourth Edition.*

By G. L. Jenkins, W. H. Hartung, K. E. Hamlin, and J. B. Data. John Wiley & Sons, New York; Chapman & Hall, London. $10.75. x + 569 pp.; ill. 1957.

This popular student textbook has been revised to bring it abreast of the recent developments in drug therapy. Special attention has been given to the progress that has taken place in our knowledge of the chemical nature of drug actions, drug metabolism, and excretion. Typical syntheses of important medicinal agents are given and the physical and chemical properties of all the major classes of drugs are presented. The newer chemistry of the antibiotics is included in a separate chapter. One of the most provocative aspects of the book is the challenging presentation of the relationships between the physicochemical properties, stereoisomerism, and pharmacological properties of chemical substances.

C. JELLEFF CARR

MICROBIOLOGY

SYNTHESIS AND ORGANIZATION IN THE BACTERIAL CELL. *CIBA Lectures in Microbial Biochemistry.*

By E. F. Gale. John Wiley & Sons, New York;

Chapman & Hall, London. $3.50. viii + 110 pp.; ill. 1959.

The first chapter of this book should be an inspiration to all bacteriologists. Indeed, all research workers with interests bordering on the microbial or the biochemical will benefit from a reading of these 33 pages. Gale points out that fifteen to twenty years ago microbial biochemists were concerned chiefly with mechanisms of breakdown. Studies on biosynthetic reactions, especially of macromolecules and cell structures, were practically non-existent. Since that time, and chiefly within the last ten years, a revolution has taken place in this area of microbial biochemistry. The fruits of this revolution, with respect to the composition and synthesis of the bacterial cell wall and the cytoplasmic membrane, are brilliantly reviewed in the first chapter of the book. Along with the development of this description, Gale shows that some of the antibiotics, which so rapidly came to be "known" in medicine but whose modes of action have been slower to elucidate, no longer remain so mysterious in their activities. True, the studies cited contain little mention of cell-free enzymes, but the way now appears to be open for rapid progress on this level. In addition, as Gale so well describes, there are many biologically important activities, an understanding of which requires the study of structure in relation to function rather than a study of purified chemicals in a test tube.

The other two chapters, on Amino Acid Incorporation and Nucleic Acid and Protein Synthesis respectively, will be of primary interest to workers following these special aspects of metabolism, although the presentation includes sound and concise introductions to these areas for the perusal of others. A large portion of these chapters is concerned with Gale's own more recent studies on the incorporation of labelled amino acids into peptides and proteins, and labelled purines into nucleic acids, of partially disrupted staphylococci. Some peculiarities in glutamate incorporation are interpreted by Gale to indicate hitherto undetected, additional steps in the activation, transport, and incorporation into protein of amino acids. Extensive treatment is devoted to studies on (an) "incorporation factor(s)," necessary for optimal incorporation by nucleic-acid-depleted preparations. These newer observations, involving quite complex cell brei systems, constitute data very difficult of interpretation. They would seem to require clarification with simpler systems, just as many of Gale's earlier observations, at one time puzzling, required advances in related areas before definitive interpretation became possible. But also, as in the earlier situations, Gale's data and his creative interpretations, so clearly presented in this book, point the way for further experimentation in many related areas. As in the past, they may constitute important bridges between studies on simple systems and the intact bacterial cell, which he disrupts experimentally but so admirably reconstructs intellectually.

PHILIP E. HARTMAN

ATLAS OF BACTERIAL FLAGELLATION. *By Einar Leifson. Academic Press, New York and London.* $7.00. viii + 171 pp.; ill. 1960.

The world's foremost expert on comparative aspects of flagellation in bacteria, Liefson, documents his extensive and systematic observations in meticulous fashion in this atlas. Profusely illustrated with photomicrographs of stained preparations prepared by the author, the book records both normal and aberrant types of arrangement and configuration ("wavelength" and "amplitude") of the locomotor apparatus in a wide variety of bacterial genera. Liefson's observations are of indubitable importance in determinative bacteriology. They also comprise data of interest to those concerned with problems relating to flagellar proteins and the genetic control of this biosynthesis.

PHILIP E. HARTMAN

ADVANCES IN APPLIED MICROBIOLOGY. *Volume I. Edited by Wayne W. Umbreit. Academic Press, New York and London.* $9.50. xii + 304 pp.; ill. 1959.

PROGRESS IN INDUSTRIAL MICROBIOLOGY. *Volume I. Edited by D. J. D. Hockenhull. Interscience Publishers, New York.* $8.00. viii + 248 pp.; ill. 1959.

The following quotation appears in the Preface of the first of these two books, but it could apply to the other books just as well: "This volume is the first in a series designed for the publication of critical and definitive reviews of those areas of microbiology which are of interest to the practical microbiologist.... In view of the overwhelming amount of original literature that is appearing, the need for additional reviews has been growing steadily. The reviews and essays which are already available have not primarily been written from the viewpoint of the practical microbiologist and therefore it is felt that this present series will serve a useful purpose in presenting such information within the confines of a single publication."

The respective publishers are probably the only ones who are not delighted over the simultaneous appearance of two volumes in one area. Each probably feels much like the lady whose first baby turned out to be twins. Nevertheless, the twins are not identical; in fact, only one subject appears in both volumes. The *Advances* contains an excellent review by A. L. Demain on the Mechanism of Peni-

cillin Biosynthesis. An equally fine article on the same subject, by D. J. D. Hockenhull, appears in *Progress*. Both papers must be read to gain a full appreciation of the subject, since the reviewers have approached the material in quite a different manner. Whatever is omitted by one author has been included by the other. These two reviews should be required reading for the researcher who scorns investigations motivated by the hope of a practical outcome.

The *Advances* volume contains five other reviews of fermentation processes. D. Perlman has admirably condensed almost 400 papers into a 35-page review of the Microbial Synthesis of Cobamides (Vitamin B_{12}). S. Kinoshita's review of the Production of Amino Acids by Fermentation Processes, along with a book by F. Stodola (*Q.R.B.*, 34: 259. 1959), provides interesting insight and perspective of the rapidity with which a new industrial fermentation may suddenly blossom forth. M. Hereld and J. Nečásek discuss Protracted Fermentation, the use of antimicrobial agents to reduce unfavorable effects caused by contaminating microorganisms. This review, together with a discussion of Continuous Industrial Fermentations by P. Gerhardt and M. C. Bartlett, provide background information on two interesting applications in the fermentation field which will eventually be of considerable importance in almost all fermentation processes. R. F. Robinson and R. S. Davidson present an interesting history, but an all too rosy picture of the present status, when describing the Large-Scale Growth of Higher Fungi.

Five other timely reviews are included in the *Advances in Applied Microbiology*. D. Pramer describes the Status of Antibiotics in Plant Disease control, E. O. Bennett discusses Factors Affecting the Antimicrobial Activity of Phenols, A. W. Phillips and J. E. Smith briefly describe Germfree Animal Techniques and Their Applications, S. R. Dutky appropriately introduces the reader to the field of Insect Microbiology, and W. D. Bellamy gives the present status of endeavors which eventually will lead to the Preservation of Foods and Drugs by Ionizing Radiations.

The first volume of the series *Progress in Industrial Microbiology* is almost entirely devoted to industrial fermentations. In addition to the paper on penicillin biosynthesis, mentioned above, tetracycline, riboflavin, and fat production by microorganisms are extensively reviewed. A. DiMarco and P. Penella have arranged, in almost outline form, the salient points of 78 papers and 29 patents related to the production, properties, and mode of formation of the tetracyclines. A review by T. W. Goodwin covers the Production and Biosynthesis of Riboflavin in Microorganisms. Production of Microbial Fat is described by M. Woodbine in a very comprehensive review (322 references) which includes discussions of fat composition, toxicity, and mechanisms of fat synthesis, as well as processes utilizing various bacteria, yeasts, and molds. On the other hand, W. T. Sokoloski and O. S. Carpenter have presented the subject of Microbiological Assay by use of judiciously selected examples, in order that the material might be understandable to a novice as well as helpful to the expert. This review contains a section on the general types of techniques available for assay of various biologically active agents, followed by a more specific discussion of assays utilized to estimate antibiotic potencies and a very fine summary of statistical considerations for agar diffusion assays. A critical review of the Actinomycetes, by K. A. Bisset, is quite superficial, in that little attention is devoted to recent progress in the classification of these microorganisms.

With one exception, references are arranged alphabetically in the *Advances* volume and numerically, according to order of appearance, in the *Progress* volume. P. Gerhardt and M. C. Bartlett chose to number their alphabetized references, a method which seems most appropriate for reviews of this type. A complete author index, supplied in the *Advances*, may, or may not, be more valuable than an additional 20-page review would have been. Subject indices in both books are mere skeletons, occupying only a few pages. Most of the reviews in both volumes are of broad scope and high quality. It is especially noteworthy that attention has been given to basic considerations, rather than to processes alone. These two books do much toward providing excellent summaries of "research into fermentation and other processes of a microbiological nature" (Hockenhull). We are very fortunate that both editors have promised that more volumes will be forthcoming.

PAUL A. HARTMAN

LABORATORY MANUAL FOR GENERAL BACTERIOLOGY. *Fifth Edition.*

Compiled by George L. Peltier, Carl E. Georgi, and Lawrence F. Lindgren. John Wiley & Sons, New York; Chapman & Hall, London. $4.50. viii + 295 pp.; ill. 1959.

LABORATORY PROBLEMS IN GENERAL BACTERIOLOGY. *By Edward G. Berry and Robert M. Pengra. Burgess Publishing Co., Minneapolis.* $2.00 (paper). viii + 45 pp.; ill. 1959.

LABORATORY INSTRUCTIONS IN MICROBIOLOGY. *Second Edition.*

By Louis P. Gebhardt and Dean A. Anderson. The C. V. Mosby Co., St. Louis. $3.75 (paper). 261 pp.; ill. 1958.

DETERMINATIVE BACTERIOLOGY. *Laboratory Manual. Second Edition.*

By Thomas H. Lord. Burgess Publishing Co., Minneapolis. $3.25 (paper). vi + 134 pp. 1959.

LABORATORY MANUAL IN GENERAL BACTERIOLOGY.

By Eric Fowler and C. H. Werkman. Burgess Publishing Company, Minneapolis. $3.00 (paper). v + 103 pp.; ill. 1957.

The manual "compiled by" (not the usual, assuming, "by") Peltier et al. contains a thorough content of classical laboratory *exercises*. Berry and Pengra supply a shorter, more diversified series of laboratory problems with an unusual amount of experimental flavor. Gebhardt and Anderson is the choice, however, if a sequence of very elementary classical exercises is required or if supplies of bacteriological media and equipment are very limited.

Only one of the manuals, that by Berry and Pengra, really gives experience in the actual preparation and sterilization of media by students, a responsibility which could conceivably be delegated with benefit to some of them in connection with experiments early in the courses. With the same exception, the introductory experiments are performed with pure cultures given to the students. Only quite late in the courses do students themselves isolate bacteria in pure culture (in exercise 22, of 39; exercise 11, of 29; exercise 18, of 68). After this belated beginning, bacteria are repeatedly cultivated from a tremendous variety of sources. The isolates are scantily characterized and rarely used in further experiments. One very nice exception to this is to be found in Gebhardt and Anderson: *Staphylococcus* isolates are utilized in a phage-typing experiment. The same manual is the only one to contain more than a trace of serological education; one assumes that this deficiency is made up in a separate course with its separate manual, separate grade, and separate specialists in command. The presentations of bacterial metabolism are almost exclusively based on the classic and diagnostically important degradative enzymes. The Berry and Pengra manual contains an experiment on a bacterial enzyme (glucose dehydrogenase) as a demonstration. It is not difficult for students to grow mutant strains blocked in biosynthetic pathways and to detect accumulated and excreted intermediates chromatographically, to test growth responses on intermediates, or to examine the strains for cross-feeding, etc. Bacterial growth curves, which require entry into the laboratory outside of "class hours" one day (or evening) during the course, are excluded in all manuals except that of Berry and Pengra. Few experiments requiring quantitative work are presented in any of the manuals. And, in Fowler and Werkman, the weakest manual of the group, dilution and plating techniques appear only in exercise 35 (of 39)! Lord's manual stresses staining procedures and growth characteristics of a wider range of the more commonly encountered bacteria than do the other manuals. Perusal of the manuals gives barely a hint of the role of bacteria in modern biology. Indeed, one must consult the title pages to be sure what decade they have been published in.

PHILIP E. HARTMAN

LA SEXUALITÉ DES BACTÉRIES. *Monogr. Inst. Pasteur. By E. L. Wollman and F. Jacob; préface by André Lwoff. Masson & Cie., Paris.* 3,000 fr. (paper). xvi + 247 pp. + 4 pl. 1959.

This book is a review of what is known at present about the sexual system in the bacterium *Escherichia coli*. Although Lederberg and Tatum discovered recombination in *E. coli* in 1946, our present understanding of this mating system is in large part due to the imaginative and inventive work done over the last six years by the authors of this book.

Not only is the story revealed by Wollman and Jacob a most absorbing one, but the technics the authors have devised to bring clarity to what at first appeared to be a refractory system are most ingenious. The cast of characters in this book includes not only bacteria, but bacterial viruses and newly revealed virus-like elements, both of which can associate with the genetic material of the bacterial cell. Among these virus-like elements is the determinant of sexuality.

Anyone interested in the origin of viruses, or the evolution of sexuality, is certain to be stimulated by this book. Although it is a detailed account, it is well paced for the uninitiated reader. It is to be hoped that the book will soon be translated into English so that it may captivate a larger audience.

R. S. EDGAR

EXPERIMENTS IN SOIL BACTERIOLOGY. *Third Edition.*

By O. N. Allen. Burgess Publishing Company, Minneapolis. $3.00 (paper). viii + 117 pp. 1957.

EXPERIMENTAL PATHOGENIC MICROBIOLOGY.

By John M. Slack, James E. Dyson, and William K. Harrell. Burgess Publishing Company, Minneapolis. $3.65 (paper). xiv + 146 pp.; ill. 1959.

MANUAL OF MEDICAL VIROLOGY.

By S. S. Kalter and J. E. Prier. Burgess Publishing Company, Minneapolis. $3.50 (paper). 127 pp.; ill. 1957.

Allen's manual is designed for use in a course for students with major interests in agricultural bacteriology, soils, chemistry, and agronomy. Its organization is good, and interesting experiments with pure cultures of a restricted number of groups of

organisms are provided: on nitrification, sulfur and iron bacteria, nitrogen fixation, etc. The manual by Slack, Dyson, and Harrell contains the standard series of bacteriological exercises given to medical microbiology students. Several good experiments with viruses are included, as well as a few other experiments on "caries susceptibility tests." Kalter and Prier outline in the first third of their manual several serological and growth experiments with viruses. The remainder of the manual is devoted to extensive summaries of the properties of animal viruses and rickettsia.

PHILIP E. HARTMAN

THE VIRUSES. *Biochemical, Biological, and Biophysical Properties. Volume 2: Plant and Bacterial Viruses.*

Edited by F. M. Burnet and W. M. Stanley. Academic Press, New York and London. $13.00. xvi + 408 pp.; ill. 1959.

Remarkable is the ingenuity of the Academic Press in concocting expensive treatises containing surveys of diverse biological subjects. Fortunately for the microbiologist, devoted and experienced scientists have in this instance surpassed the publishers in ingenuity (or, at least, "have taken them off the hook"!). The result is a series of thorough and comparatively well-coordinated reviews of the basic properties of plant and bacterial viruses. Factual information concerning steps in bacteriophage infection is described by A. Garen and L. M. Kozloff (attachment and invasion), and by G. S. Stent (multiplication). Cogent résumés of phage genetics (C. Levinthal) and lysogeny (F. Jacob and E. L. Wollman) complete the more general treatments on bacteriophages. A beautifully clear and organized discussion of the radiobiology of bacteriophages is described by F. W. Stahl. Although of a more specialized nature, this article perhaps is the highlight of the volume. The group of articles on bacteriophages, which would appear to need no introduction, is nevertheless introduced by A. Lwoff. He all too sparklingly outlines some basic properties of viruses in a seemingly logical fashion, concomitantly developing a definition of these agents which, at the same time, excludes cellular organelles. Useful as such a definition at first seems to be, the change from virus to organelle, and back, under Lwoff's criteria would appear to require a change in a single nucleotide pair in the genetic element. Plant viruses (tobacco mosaic virus infection and multiplication) receive exhaustive treatment (S. G. Wildman); and there are chapters on biochemistry (R. Markham), variation (C. A. Knight), and insect vectors (L. M. Black). Although the states of development of the various areas treated differ widely, each of the authors has compiled and developed a wealth of material into comprehensible form.

PHILIP E. HARTMAN

PLANT VIRUS SEROLOGY.

By R. E. F. Matthews. Cambridge University Press, New York. $5.00. xii + 128 pp. + 7 pl.; text ill. 1957.

Although serology has been used by plant virologists for some twenty years, the only previous general discussions of plant virus serology are K. S. Chester's *Critique of Plant Serology*, published in 1937 in *The Quarterly Review of Biology*, and a condensed account in F. C. Bawden's general text, *Plant Viruses and Virus Diseases* (*Q.R.B.*, 26: 297. 1951). Consequently, this book fills a need long felt by plant virologists.

Matthews' book is, as indicated by its subtitle, both a general survey of experimental methods and a presentation of practical instructions. The general survey is sufficient to give those not trained in serology a general understanding of the subject, a knowledge of the general areas in which serological techniques are particularly useful, and an appreciation of the limitations of these techniques. The practical instructions for the standard techniques are sufficiently detailed to give the beginner the correct start in using serological procedures for virus identification and quantitative assay and for the routine testing of plants for freedom from virus infections. Sources of variations, the causes of false reactions, and the reasons for reaction failures are discussed in detail, and instructions on how to minimize these troubles are given. For this reason, and also because the author enriches each chapter with his personal experiences, the book will also be found useful by experienced workers in the field.

Major attention is given to the precipitin reaction, for to date this reaction has proved to be the most generally useful serological technique for work with plant viruses. Nevertheless, many potential users of the book will doubtless be disappointed that the treatments of other techniques are not equally detailed. Many also will regret the author's failure to do little more than mention some of the newer special techniques, such as the gel-diffusion method and the use of adjuvants. No doubt this is an unfortunate matter of timing.

The writing in general is concise, a good illustration that a lot of precise information can be packed into relatively few pages. The book is amply illustrated, with photographs to illustrate techniques plus graphs and diagrams to supplement the text and to demonstrate the kind of results to be expected.

Although serologists who work with other types

of antigens will find this book of little practical value, the information presented on the serological reactions of the plant viruses should be of interest to them. Some of these nucleoproteins can be obtained in large amounts and are relatively homogeneous serologically, characteristics making them quite suitable for certain "model" experiments.

A. F. Ross

THE BACTERIOLOGY OF TUBERCULOSIS.

By Egons Darzin. University of Minnesota Press, Minneapolis. $10.00. xii + 488 pp.; ill. 1958.

In compiling and writing this book, Darzin has performed a real service for mycobacteriologists. In accordance with his stated intention, the material has been chronologically ordered and presents a clear sequential picture of the historical development of this subject. In addition, the book is very complete and current in its coverage of the field. As a source of reference for both the academic researcher as well as the clinically oriented investigator, this volume should prove to be a welcomed addition to the library shelf.

Especially well presented is the last section, Part V of the book. Concerned with problems encountered in experimenting with tubercle bacilli, this material should be received with great appreciation by initiates into mycobacterial research.

ROBERT C. PARLETT

STAPHYLOCOCCUS PYOGENES *and Its Relation to Disease.*

By Stephen D. Elek. E. & S. Livingstone, Edinburgh and London; [The Williams & Wilkins Company, Baltimore]. $15.00. viii + 767 pp.; ill. 1959.

The growth of scientific knowledge concerning an individual species and its relation to disease is illustrated by this fine compilation of observations bearing directly or indirectly on *Staphylococcus pyogenes* (*Staph. aureus*). Close to 4,500 references (through 1957) are cited complete with titles, although the author has omitted from consideration numerous other articles of medical interest. He focuses attention, instead, upon a description of the morphology, metabolism, structure, and variation of the microbe itself, its distribution in nature, its release of toxic substances, and its action in disease. Elek, who himself has contributed to this area of investigation, has compiled a thorough and well-balanced survey of this group of organisms. The material is concisely presented, and conveniently and logically arranged. Although almost concealed by the final extensive author index, a short subject index adds to the book's usefulness as a reference work. In general, the more important contributions to the subject receive due emphasis; however, critiques are brief and generalizations scarce. This is an opportune time for the publication of this book, since the staphylococci are receiving a renewed burst of attention because of their hardiness in the presence of commonly used antibiotics. Let us hope that a good part of this attention will follow Elek's lead in the determination of some basic attributes of the organisms themselves.

PHILIP E. HARTMAN

HEALTH AND DISEASE

MEDICAL SCIENCES. *Progress in Nuclear Energy. Series VII. Volume 2.*

Edited by J. C. Bugher, J. Coursaget, and J. F. Loutit. Pergamon Press, New York, London, Paris, and Los Angeles. $15.00. viii + 240 pp.; ill. 1959.

The Second International Conference on the Peaceful Uses of Atomic Energy was held in Geneva in September, 1958, under the auspices of the United Nations. The Proceedings of this conference published by the United Nations fill thirty-three volumes. The editors of the Pergamon Press have selected certain papers for inclusion in a series of twelve volumes entitled *Progress in Nuclear Energy.*

The present book is Volume 2 of the Medical Sciences series. In the opinion of the editors (but not of this reviewer) the volume represents the content of the conference as faithfully as possible and is not an expression of their personal feelings about the relative merits of the various subdivisions of the agenda.

Twenty-five papers are presented. Of these, ten are in the area of radiation therapy, twelve are concerned with radiation biology and hygiene, and three are in general medical areas. One of the latter articles is a survey article on the use of radioactive isotopes in medicine.

One must agree with the editors that papers of substantial scientific merit have been omitted. They state that this was done to maintain the relative emphasis of the conference. Taking a broad perspective, one will agree also that the papers on radiation biology and hygiene are of great importance. However, in the present volume, far too much emphasis is placed on radiation therapy. The exciting applications of radioisotopic techniques to the solution of medical problems, particularly in the fields of biochemistry and biophysics, seem to have been neglected.

Unfortunately, the editors did not supplement the United Nations publications by presenting critical review articles, but rather merely duplicated

papers taken chiefly from Volume 26 of the Official Proceedings in an uncritical fashion.

The book will be of value to radiotherapists, but it is not recommended for physicians or biologists desiring a broad perspective of progress in nuclear energy.

HENRY N. WAGNER, JR.

HEMOPHILIA AND OTHER HEMORRHAGIC STATES. *International Symposium, Rome.*

Edited by Kenneth M. Brinkhous; assistant editor, Pietro de Nicola. The University of North Carolina Press, Chapel Hill. $7.50. xx + 266 pp.; ill. 1959.

In 1657, a few weeks before his death, William Harvey wrote as follows:

> Nature is nowhere accustomed more openly to display her secret mysteries than in cases where she shows traces of her workings apart from the beaten path; nor is there any better way to advance the proper practice of medicine than to give our minds to the discovery of the usual law of Nature by careful investigation of cases of rarer forms of disease. For it has been found, in almost all things, that what they contain of useful or applicable nature is hardly perceived unless we are deprived of them, or they become deranged in some way.

It was Sir Archibald Garrod, father of "inborn errors of metabolism," who called attention to this "quotable quote" (*Lancet*, 1: 1055. 1928). There is no better example of the principle expounded by Harvey than that provided by the several hereditary defects of the clotting mechanism. At least six factors essential to normal clotting are now known only because of the occurrence of an equal member of hereditary deficiencies.

The symposium on hemophilia and hemorrhagic states which was held in Rome in 1958 has many useful features, especially genetical. Two cases of female hemophilia are reported. Two simple tests for distinguishing hemophilias A and B are described. A considerable portion of the symposium is devoted to a group of papers on a nosologically confused group of hemorrhagic states characterized by prolonged bleeding time and variously termed angiohemophilia, vascular hemophilia, pseudohemophilia A and B, von Willebrand's disease, constitutional thrombopathia, and others. The prototype of this group was described by Willebrand in 1926 in residents of the Åland Islands lying in the Baltic Sea between Sweden and Finland.

The Hageman factor is essentially unique among those described in recent years because, although its lack is inherited, no symptoms whatever accompany its deficiency. In fact, the physiologic and pathologic implications of the Hageman factor or a defect therein are totally unknown. First described by Ratnoff and Margolius of Cleveland in 1955, it is also called the "glass factor" or the "contact factor" because it is activated by contact with glass. A defect results in prolonged clotting time in vitro. Margolis of Sydney pointed out that contact between glass and the Hageman factor initiates a series of reactions ending not only in clotting but also in the release of a pain-producing and smooth-muscle-activating polypeptide and activation of a permeability factor. He speculated that silica dust (in the lung, for example) might be handled differently in persons with the defect and that the Hageman factor might be a remnant of a phenomenon of biological importance in the past. Study of the comparative physiology of the Hageman factor might elucidate the latter question.

McCain, Chernoff, and Graham studied the inheritance of the Hageman trait in four unrelated families ascertained in hospitals in which a simple in vitro clotting time test is performed routinely before surgical operations. In two of the families there was consanguinity. Both males and females, and both Caucasians and Negroes, were affected. There was no direct transmission. In the three informative sibships there were 6 affected members as compared with 6.0084 expected by the Lenz-Hogben method, assuming inheritance as an autosomal recessive. Existing techniques proved inefficient in identifying heterozygotes.

VICTOR A. MCKUSICK

CONNECTIVE TISSUE, THROMBOSIS, AND ATHEROSCLEROSIS. *Proceedings of a Conference Held at Princeton, New Jersey, May 12–14, 1958.*

Edited by Irvine H. Page. Academic Press, New York and London. $9.50. x + 316 pp.; ill. 1959.

Irvine H. Page was asked in 1953 by the National Research Council and the Air Force Directorate of Research and Development to organize a symposium to summarize what was known about atherosclerosis at that time. The proceedings were published in 1955. Later the National Advisory Heart Council of the U.S.P.H.S. asked him to organize a Symposium of Lipid Chemistry which was held in 1957 and published in 1958. The symposium reviewing the relationship between connective tissue and atherogenesis, held at Princeton in May, 1958, was a logical sequel to the earlier ones. The problem of thrombosis and fibrinolysis was also included in the discussion.

J. B. Duguid of Newcastle-upon-Tyne reviewed the evidence for his thesis that the primary lesion in atherosclerosis is fibrin deposition. F. O. Schmitt, David S. Jackson, Jerome Gross, and Melvin J. Glimcher reviewed general aspects of collagen

chemistry which are probably pertinent to atherogenesis. The problem of the ground substance in arteries was not covered in detail because of the recently publishred CIBA symposium *Chemistry and Biology of Mucopolysaccharides*. However, Karl Mayer reviewed the chemistry of ground substances. Albert I. Lansing, long a student of elastic tissue and the changes therein as a factor in atherogenesis, spoke on this topic. Boucek and his colleagues addressed themselves to the matter of the properties of the fibroblasts, especially as revealed by their technique of sponge implantation. Oscar Ratnoff, Tage Astrup, Sol Sherry, and Kurt N. von Kaulla discussed thrombosis and fibrinolysis.

VICTOR A. MCKUSICK

PROGRESS IN DRUG RESEARCH. *Volume I.*

Edited by Ernst Jucker. Birkhäuser Verlag, Basel and Stuttgart. sFr. 68. 607 pp.; ill. 1959.

This volume is the first of a new series to survey current aspects of pharmacology and medicinal chemistry. Subsequent volumes will appear yearly. Each of the 7 chapters reviews developments within a specific research area. Survey articles are planned to present some aspects of the relationships between the structure and the pharmacologic activity of certain groups of groups.

Volume I contains the following articles: Ion exchange resins and their use in pharmacy and medicine (von J. Buchi); Cholesterol and its relation to atherosclerosis (Tsung-Min Lin and K. K. Chen); The chemotherapy of worm infestations (von H.-A. Oelkers); Newer aspects of the chemistry of anthelmintic research (von J. Bally); The placebo problem (von H. Haas, H. Fink, and G. Hartfelder); Stereochemical factors in biological activity (A. H. Beckett); and A review of new drugs of the last five years (von W. Kunz).

C. JELLEFF CARR

ANTIBIOTICS ANNUAL. *1958–1959. Proceedings of the Sixth Annual Symposium on Antibiotics, October 15, 16, and 17, 1958, Washington, D. C.*

Edited by Henry Welch and Felix Marti-Ibañez. Medical Encyclopedia, New York. $12.00. xx + 1107 pp.; ill. 1959.

This volume contains the 184 papers presented at the 1958 Antibiotics Symposium, with a subject and author index. The book is most useful as documentation of the kaleidoscopic, rapidly changing pattern of antibiotic research and clinical use. The causation, prevention, and control of staphylococcal disease in hospitals was one of the major concerns of the conference.

C. JELLEFF CARR

BCG VACCINATION AGAINST TUBERCULOSIS.

By Sol Roy Rosenthal; sections by C. Guerin, B. Weill-Halle, and A. Wallgren. Little, Brown and Company, Boston. $7.50. ix + 389 pp.; ill. 1957.

LA SOUCHE DU BCG.

By A. Frappier and M. Panisset. Institut de Microbiologie et d'Hygiène de l'Université de Montréal, Montréal. $4.75. 120 pp. 1957.

In the Preface to his book, Rosenthal states that his purpose in writing it is to present to "the medical profession and allied groups in the United States" material which might help to answer some of the questions which have arisen regarding the use of the BCG vaccine. An honest attempt to present objectively all pros and cons of the subject has been made. I do not believe that it was the author's intention to resolve major issues, and the book should not be read with this intent.

The Canadian monograph also contributes much toward allowing each reader to evaluate accurately the efficacy and value of BCG vaccination. Interesting data from large-scale vaccination studies undertaken in Canada are given. In addition, this work contains a fine chronological evolutionary history of the BCG strain.

Although there is some overlap of the subject matter contained in both volumes, each contributes uniquely, both in philosophical approach and in factual material. The combined effect is a full presentation of the origin, historical development, present status, and possible future of BCG vaccination. For maximum value and effect it is recommended that these two works be read concurrently.

ROBERT C. PARLETT

THE USE OF RADIO-ACTIVE ISOTOPES IN THE STUDY OF EXPERIMENTAL TUBERCULOSIS. *Monographie de l'Institut de Microbiologie et d'Hygiène de l'Université de Montréal.*

By Joseph Sternberg. S. Karger, Basel and New York. $15.35. iv + pp. 248–343; ill. 1958.

A very concisely written volume, this book serves well as a valuable source for reference and as a handbook for investigators in this special field. Although the book is oriented toward the application of radioactive materials in studies of tuberculosis, much of the information is of such a nature that it applies equally well to other biological experiments. This book presents a practical, general review of basic concepts of isotopes, a thorough understanding of which is essential for the intelligent use of these materials. Consideration is given also to some of the possible pitfalls which one might encounter in designing new techniques or investigations using radioactive elements.

The author discusses other important aspects relative to experimental planning and emphasizes the importance of choosing isotopes suitable for the individual studies. He points out that careful consideration of such factors as the type of ray emitted and measured, the half-life of the isotope, the selection of optimal measuring devices, and the better forms for presenting published data is of extreme importance for a successful investigation.

In general, the wealth of information which the reader may obtain from this book will provide a solid basis for critical evaluation and a more thorough comprehension of the published results obtained from radioactive isotope studies of experimental tuberculosis and similar experimental work.

ROBERT C. PARLETT

THE MEDICAL AND VETERINARY IMPORTANCE OF COCKROACHES. *Smithson. misc. Coll., Vol. 134, No. 10, Pub. 4299.*

By Louis M. Roth and Edwin R. Willis. Smithsonian Institution, Washington. Free upon request (paper). iv + 147 pp. + 7 pl. 1957.

In the authors' words, this paper "is a documented summary of the tangled relations between cockroaches and the organisms that cause disease in man and other animals." The material is presented as 48 pages of discussion, 63 pages of appendices, 26 pages of bibliography, an index, and table of contents. The discussion relates habits of roaches to pathogens and to cause of diseases and injury to man. It summarizes the literature on roaches in medical lore and mentions instances where they have been incorrectly related to pathogens. The five appendices contain supporting data for the discussion and are arranged according to groups of pathogens such as viruses, bacteria, fungi, protozoa, and helminths. The bibliography is extensive. The index is well arranged and dependable.

I have found this publication valuable in my own work as a teacher of medical entomology and in preparation for lectures. It should be useful to medical practitioners, sanitarians, and public health officials because the rising incidence of cockroaches, their habits of ranging widely, and their capability as vectors of enteric agents demand attention.

WILLIAM R. HORSFALL

PSYCHOLOGY AND ANIMAL BEHAVIOR

THE CENTRAL NERVOUS SYSTEM AND BEHAVIOR. *Transactions of the First Conference, February 23, 24, 25, and 26, 1958.*

Edited by Mary A. B. Brazier. The Josiah Macy, Jr. Foundation, New York; The National Science Foundation, Washington. $5.25. 450 pp. + 1 pl.; text ill. 1959.

The complete title of this book should undoubtedly be *The Central Nervous System and Behavior in Past and Present Russia.* The first half is given to Russia's past in the following areas: an instructive and interesting pictorial survey in 107 figures (W. H. Magoun, Louise Darling, and Mary A. B. Brazier); a compressed yet comprehensive discussion of the 19th century and of Sechenov (Mary A. B. Brazier); a similar discussion of Danilevsky, Wedensky, and Ukhtomsky (C. D. Leake); a somewhat longer treatment of Pavlov (W. H. Gantt); and a much-needed treatment of Bekhterev (P. I. Yakovlev). Russia's present contributions are taken up in four articles: Post-Pavlovian development in conditional reflexes (H. S. Liddell, James Olds, and R. W. Sperry—Summation, C. E. Leese); Brain stimulation and conditional reflexes (R. W. Doty); Electroencephalographic studies of conditioned learning (Frank Morrell); and Electrical correlates of conditioned learning (Robert Galambos—Summation, R. B. Livingston). As noted, the book is a published transaction of a conference; 14 discussants, besides the aforementioned 14 main participants, took part in it.

It is not difficult to see that the conference covered much more the historical background than the present status of Russian neurophysiological research and thought. For, obviously, studies of electrophysiological correlates of conditioning, with which three of the four sections of the second half of the book deal, constitute only a small portion—my estimate would be about 8 per cent—of such current research and thought. Yet this portion is no doubt very significant, and perhaps it was the intention of the Conference to highlight merely one aspect of the total area. If so, the Conference was surely successful, although perhaps only in part, since, to judge by the appended references, even in this particular aspect only a small number of reports of Russian experiments were available to its participants. The language barrier is indeed serious, and the Conference is to be congratulated for attempts to break through it and to stimulate cooperation between American and Russian scientists in an area in which the Russians' share is not at all of mean magnitude, and is a share that as a rule has been, and still is, imbued with a strong spirit of pioneering.

GREGORY RAZRAN

THE FIFTH MENTAL MEASUREMENTS YEARBOOK.

Edited by Oscar Krisen Buros. The Gryphon Press, Highland Park, New Jersey. $22.50. xxx + 1292 pp. 1959.

The first section of this important reference book

is Tests and Reviews, and has as its objective the presentation of comprehensive information on recent tests published in English-speaking countries, together with critical reviews of specific tests that should aid test users in making their selections. The individual reviews also serve the purpose of acquainting the test user with the criteria used in evaluating a test and should increase awareness of the problems involved in test selection and application. It is to be hoped that the emphasis on the importance of adequate standardization of tests will not pass unnoticed by test publishers and prospective test users.

Specific tests are accompanied by extensive references to published studies where the test was investigated or otherwise used. Information on specific tests includes name of test, description of groups for which the test is intended, date of copyright or publication, information on any subscores, reliability, validity, cost, time required for administration, and the name of author and publisher.

The alphabetical classification of tests in the first section is into the categories Achievement Batteries, Character and Personality, English, Fine Arts, Foreign Languages, Intelligence, Mathematics, Miscellaneous, Multi-Aptitude Batteries, Reading, Science, Sensory Motor, Social Studies, and Vocations. There are many subdivisions within this gross classification.

The second section, Books and Reviews, is a bibliography of recent books on measurement and on books in related fields. These reviews should be of considerable assistance to test users interested in selecting books relevant to their particular needs. Books that the editor feels merit review are also listed, even though they have not been reviewed.

Reference use of this volume is facilitated by an alphabetical list of test publishers, an alphabetical index of test titles, an index of authors of tests, reviews, books and research articles, and an index of tests classified by type of test.

The task of publishing a series such as these *Yearbooks* becomes staggering with the constant increase in the number of tests published; however, the product of these labors should be appreciated by all concerned with the ever-growing field of testing.

JAMES L. KUETHE

PRENATAL AND PARANATAL FACTORS IN THE DEVELOPMENT OF CHILDHOOD READING DISORDERS. *Monographs of the Society for Research in Child Development, Vol. 24, No. 4.*

By Ali A. Kawi and Benjamin Pasamanick. Child Development Publications, Lafayette. $3.00 (paper). 80 pp.; ill. 1959.

HUMAN BIOLOGY

CORAL ISLAND. *Portrait of an Atoll.*

By Marston Bates and Donald P. Abbott. Charles Scribner's Sons, New York. $4.95. 254 pp.; ill. 1958.

Too often accounts of life in the South Seas sound as if the authors had read too much Conrad or the memoirs of some French anthropologist, sampling native customs not wisely but too well. This book is a straightforward account of life on an isolated atoll as a scientific party found it, of the people and what they did, and of the scientific party and its activities. These two diverse ethnic groups seem to have adjusted themselves to each other remarkably well, and it is obvious to the reader that the people of Ifaluk must have as mellow memories of the visiting naturalists who returned to their own strange civilization as do the naturalists of the people of the atoll. Since both authors obviously wanted to say things their own way about their experiences, they finally compromised by writing the book in halves. The first nine chapters are by Bates, Chapters 10 to 17 by Abbott. The two authors complement each other well, and a casual reader who dips into one part or the other will hardly be aware of the change. What confusion there is arises from the nomenclatorial change in the name of the ichthyologist, for which the publishers have supplied a belated errata slip. This is a book which anyone interested in or planning to work among primitive peoples will find invaluable, and it will be read long after more sensational or journalistic accounts are forgotten.

J. W. HEDGPETH

BIOMETRY

EXPERIMENTAL DESIGNS IN INDUSTRY. *A Symposium held November 5–9, 1956, at North Carolina State College.*

Edited by Victor Chew. John Wiley & Sons, New York; Chapman & Hall, London. $6.00. xii + 268 pp.; ill. 1958.

This book contains 9 papers presented in a symposium directed towards industrial uses of experimental designs, but undoubtedly biologists will get a new slant on certain problems by studying the papers. The differences between industrial and nonindustrial uses of designs have, in my own opinion, been vastly overrated. The differences are all a question of degree. In some industrial situations observations are expensive and come in sequence, but in biological experimentation these aspects can also prevail. In some industrial experimentation there are physical laws which can be used to form an idea of the form of input-output relationships. In a few nonindustrial situations there are laws which serve the same purpose, but clearly there is considerably less such information. The logical problems of experimentation seem to be rather constant. All the papers, therefore, are relevant to any sort of experimentation, just as Fisher's *Design of Experiments*, which discussed primarily agronomic experiments, is relevant.

Three of the papers, by V. Chew, R. L. Anderson, and G. E. P. Box and J. S. Hunter, review experimental designs. They will be useful side-reading to material presented in the various textbooks now available. A paper by R. J. Hader and A. H. E. Grandage gives the standard material relating to multiple regression analysis. Five papers by W. S. Connor, W. H. Horton, M. B. Carroll and O. Dykstra, R. M. DeBaun and A. M. Schneider, and C. A. Bicking discuss industrial experiences with experimental designs of the various types.

Most of the review papers suffer from an attempt to compress what would be a sizeable part of a textbook into a paper. Perhaps as a consequence of this, there is insufficient discussion of the basic logic and difficulties in the application of the logic. As an example of the latter type of defect, does the wide use of randomized blocks take into account the real logical difficulty that a randomized block experiment may give a biased estimate of error because of non-additivity? Again, as this reviewer has remarked a number of times, is not the dependence of the methods of Box on choice of units a matter of misgiving? Formulas and procedures that can be applied mechanically undoubtedly appeal to some experimenters, but the more perspicacious experimenters will not be satisfied unless the logical bases are laid out clearly and both deficiencies and strengths discussed. The paper on actual experiences will be useful reading for anyone interested in applications of statistical design of experiments.

The volume also contains a very useful bibliography of theory and use of experimental designs. In summary, this collection of papers will serve a very useful purpose with both experimenters and students.

OSCAR KEMPTHORNE

DE OMNIBUS REBUS ET QUIBUSDAM ALIIS

GERMAN-ENGLISH SCIENCE DICTIONARY *for Students in Chemistry, Physics, Biology, Agriculture, and Related Sciences. Third Edition including Supplement of New Terms.*

By Louis De Vries; with the collaboration of members of the Graduate Faculty (Iowa State College). McGraw-Hill Book Company, New York, Toronto, and London. $7.00. xliii + 592 pp. 1959.

The third edition of this extremely useful dictionary is essentially a new printing of the second (1946) edition (*Q.R.B.*, 22: 104. 1947), plus over 3,000 alphabetically arranged new terms and modernized translations. The author states that these new entries were placed in a separate section "for the sake of expediency"; we assume expediency to refer here only to time of publication and retention of a reasonable price, not to utility for the user. The clear type, extreme compactness, and excellent choice of both scientific and common-language words, along with the brief and apt translations, are preserved and extended from the old edition. These are the attributes which have made De Vries' dictionaries so valuable an aid to biologists, chemists, and physicists. A new 25-page section on "suggestions for translators" consists of a briefing on sentence structure, a listing of commonly used irregular verbs, and some principles of German grammar.

PHILIP E. HARTMAN

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Animal Sounds and Communication

Edited by: W. E. LANYON and W. N. TAVOLGA of
The American Museum of Natural History

Students of animal behavior and biological acoustics will welcome publication of this series of papers in their rapidly developing and overlapping areas of study. The volume contains the proceedings of a symposium organized by the *Section of Animal Behavior and Sociobiology*, Ecological Society of America and American Society of Zoologists, and held at the AIBS meetings at Indiana University in August 1958. Two additional chapters have been included on material not represented in the original symposium. A standard 12 inch LP Record, prepared from tape recordings that accompanied the papers at the Indiana meeting, is included with the volume to illustrate the principles discussed in each chapter. Many of these recordings are further analyzed visually by sound spectrograms.

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